ANAPHORIC REFERENCE TO PROPOSITIONS

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Just as pronouns like *she* and *he* make anaphoric reference to individuals, English words like *that* and *so* can be used to refer anaphorically to a proposition introduced in a discourse: *That's true; She told me so*. Much has been written about individual anaphora, but less attention has been paid to propositional anaphora. This dissertation is a comprehensive examination of propositional anaphora, which I argue behaves like anaphora in other domains, is conditioned by semantic factors, and is not conditioned by purely syntactic factors nor by the at-issue status of a proposition.

I begin by introducing the concepts of anaphora and propositions, and then I discuss the various words of English which can have this function: *this*, *that*, *it*, *which*, *so*, *as*, and the null complement anaphor. I then compare anaphora to propositions with anaphora in other domains, including individual, temporal, and modal anaphora. I show that the same features which are characteristic of these other domains are exhibited by propositional anaphora as well.

I then present data on a wide variety of syntactic constructions—including subclausal, monoclausal, multiclausal, and multisentential constructions—noting which license anaphoric reference to propositions. On the basis of this expanded empirical domain, I argue that anaphoric reference to a proposition is licensed not by any syntactic category or movement but rather by the operators which take propositions as arguments.

With this generalization in hand, I turn to how such facts can be formally modeled: I review existing systems which track anaphora and/or which make use of propositional variables, and then introduce a new formalism which incorporates insights from these existing systems.

Finally, I turn to the interaction between a proposition's availability for anaphoric reference and its discourse status (in particular, its at-issue status). Contrary to the prevailing assumption in the literature, I argue that there is no tight linking between these two properties, and that one of the tests frequently used to diagnose at-issueness in fact diagnoses only anaphoric availability. I argue that propositional anaphora and at-issueness are distinct, showing that at-issueness is neither necessary nor sufficient to determine a proposition's anaphoric potential.

BIOGRAPHICAL SKETCH

Todd Snider received his B.A. in Linguistics and Mandarin Chinese from Carnegie Mellon University, during which time he also studied abroad at Shanghai International Studies University. He wrote his B.A. Honors Thesis, "The Semantics of Prepositions: An exploration into the uses of *at* and *to*", under the advisement of Mandy Simons. He is graduating from Cornell University with a Ph.D. in Linguistics and a graduate minor in Cognitive Science, working under co-chairs Sarah Murray and Mats Rooth, as well as Will Starr (Philosophy) and John Whitman. During his time as a Ph.D. student, Todd has presented at distinguished international conferences in his area, including Semantics and Linguistic Theory (SALT), Sinn und Bedeutung (SuB), and the West Coast Conference on Formal Linguistics (WCCFL). While at Cornell, Todd coordinated the interdisciplinary Semantics Research Group for 3 years, edited the Proceedings of SALT, and served as a voting member of the Graduate & Professional Students Assembly. Starting in the Fall, he'll start a Postdoctoral Research Fellowship at the Language, Logic, and Cognition Center at the Hebrew University of Jerusalem.

To those who exercise empathy.

To those who are, above all else, kind.

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בָּרוּךְ אַתָּה יְיָ אֱלֹהֵינוּ מֶלֶךְ הָעוֹלָם, שֶׁהֶחֱיָנוּ וְקִיְּמָנוּ וְהִגִּיעָנוּ לַזְּמַן הַזֶּה.

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CHAPTER 1

INTRODUCTION

This dissertation investigates the nature of *propositional anaphora*, wherein a word refers back to the sort of entity denoted by a declarative sentence, among other things. Consider the exchange in (1), in which comedian and talk show host Stephen Colbert prepares to cajole his guest (and friend) Steve Carrell into performing alongside him.

(1) COLBERT: People still don't know that you're a great singer.
CARRELL: Mm, well, that's not really true. But, thank you.
COLBERT: That you're a great singer-
CARRELL: Yes
COLBERT: or that people don't know?
CARRELL: That I'm a great singer. But that's nice of you to say.
COLBERT: Do people- do you guys- Are aware that he's a great singer?
[audience cheers]
COLBERT: No one knows that, Steve Carrell. . . . Let's do a song.

(The Late Show with Stephen Colbert, December 7, 2015)

In this exchange, what Colbert and Carrell are negotiating—explicitly—is what Carrell meant by *that* when he said *that's not really true*. This is a case where the existence of propositional anaphora becomes apparent, as it (like other anaphoric processes) is subject to ambiguity, and so sometimes requires extra work for conversational participants to successfully coordinate on a meaning. *That* in this case is a propositional anaphor, and refers to one of the two salient propositions floating around: (a) Carrell is a great singer; or (b) People don't know (a). Colbert mentions both possible interpretations, and Carrell clarifies that he was denying (a). In fact, both speakers then go on to use the same propositional anaphor *that*, to again refer to the same proposition: Carrell in *that's nice of you to*

say and Colbert in *No one knows that*.

Of course, both Colbert and Carrell are comedians, and playing around with language is par for the course. But propositional anaphora is not limited to the comedic, nor is it always so explicitly negotiated. For a more serious, and perhaps more antagonistic example of propositional anaphora in action—or more accurately, a careful use of propositional anaphora—, consider the exchange in (2), which took place during the confirmation hearing for Tom Price, then the nominee for the United States Secretary of Health and Human Services.

(2) SENATOR BROWN: President Trump said that he's working with you on a replacement plan for the ACA which is nearly finished and will be revealed after your confirmation, is that true?

PRICE: It's true that he said that, yes.

(Senate Finance Committee hearing, January 24, 2017)

In this exchange, it is clear that what Senator Sherrod Brown really wants to know is whether such a replacement plan exists. But this isn't what Price addresses, and yet he seems to somehow be following the rules of the conversational game. One might consider him sneaky, or clever, but he avoids answering the Senator's question without ignoring it. He does this by responding to one way to construe the Senator's question, where the *that* in Senator Brown's *is that true?* question tag refers not to the proposition 'President Trump is working with Price on a replacement plan…', but instead to the proposition 'President Trump said…' This question, so construed, is not the sort of thing a Senator is likely to ask at a confirmation hearing, and it's highly unlikely that Price actually interpreted the question that way. Nevertheless, he pretended to, and his response, while perhaps elusive, 'followed the rules of the game'.

These sorts of examples indicate how often we make and resolve anaphoric reference

to propositions, as well as the range of contexts in which we do so. This phenomenon is the focus of this dissertation. I will investigate the anaphors themselves, the constructions which introduce propositions into a discourse such that they can be referred to, and the relationship between them. I will discuss when such anaphoric reference to propositions is available, what mediates its availability, and discuss how to model it formally.

The sort of reference to propositions I am interested in has also been called *discourse deixis* (Webber 1988), *sentential anaphora* (Gast & König 2008), and *abstract object anaphora* (Asher 1993). Like Needham (2012), I will prefer the label *propositional anaphora* over these other terms. The term *deixis* carries a meaning relating to focus-shifting (Ehlich 1982; Cornish 1992), where some of the anaphors which take part in this process have been argued not to switch focus but to maintain it (Gundel, Hegarty & Borthen 2003; Ehlich 1982 on *it*, Needham 2012 on *so*). The term *sentential anaphora*, meanwhile, is a syntactic characterization, and one which is in fact too narrow. Part of my goal here is to investigate precisely which constructions make such anaphoric reference possible, and I show that in fact many subsentential constructions do (in Chapter 3), so the term *sentential anaphora* isn't sufficiently precise. And finally, Asher 1993 uses the term *abstract object anaphora* as an umbrella term which includes *proposition anaphora* as distinct from anaphora to events, facts, possibilities, and concepts. I carve up ontological space differently from Asher 1993, however, and will consider a range of phenomena under the umbrella of "propositional anaphora" that Asher 1993 would subdivide, in part, on the basis of head nouns which can take *that*-clause complements, like *fact*, *myth*, and *belief*. For me, these complements are all propositional, regardless of the head noun involved, and so I will call these all "propositional anaphora". I discuss the typologies of Asher 1993 and others further when I discuss the notion of a proposition in Chapter 2.

In Chapter 2, I address the question *What is propositional anaphora?* I introduce the phenomenon of anaphora broadly, and give examples of anaphora to individuals, to events,

and to propositions, the lattermost of which is the focus of the dissertation. I then introduce the notion of a proposition and its role in contemporary natural language semantics, before turning to the various anaphors of English which can pick up on propositional contents. Finally, I explore a variety of features which have been discussed as characteristic of anaphora across domains: individual anaphora, tense anaphora, and modal anaphora (Partee 1973, 1984; Stone 1997). I show that propositional anaphora, like anaphora in these other domains, exhibits these same features, including both referential and bound readings, linguistic and non-linguistic antecedents, 'donkey' examples, and strict/sloppy ambiguities. I argue, thus, that propositional anaphora is just that: anaphora.

Having looked at the anaphors themselves, I then turn to the things they refer to. I'm interested in the structures that do and don't allow for subsequent anaphoric reference. In other words, in Chapter 3, I address the question *What licenses propositional anaphora?* Karttunen (1969) introduced the term *discourse referent* to mean those things which are discussed in a text and which can be picked out by anaphors, and Karttunen 1969 was a detailed exploration of which nominal constructions introduced individual discourse referents. Chapter 3 does the same in the propositional domain, examining a wide range of constructions—subclausal, monoclausal, multiclausal, and multisentential—to determine which of them make a proposition available for anaphoric reference, that is, introduce a propositional discourse referent. In doing so, I compare the observed facts to the proposal put forward in Krifka 2013, which makes predictions about when propositional discourse referents are introduced on the basis of the presence or absence of a particular syntactic category, namely the Tense Phrase (TP). Ultimately, I argue that this type of syntactic generalization of the observed facts is untenable, and that neither syntactic category nor syntactic movement type are sufficient to capture the data. Instead, I argue that a generalization must be sensitive to the semantic type of the objects involved in a sentence's composition. And, where Krifka 2013 associates the introduction of propositional discourse referents with a clause, I argue that the introduction of discourse referents should

be attributed not to a proposition-denoting object but to the operator which takes that proposition as its argument.

Having developed a clearer picture of the empirical landscape in Chapter 3, I turn to the theoretical in Chapter 4, addressing the question *How can we model propositional anaphora?* I begin by providing background on a number of existing formal systems, including Dynamic Predicate Logic (Groenendijk & Stokhof 1991), Discourse Representation Theory (in particular that of Asher 1993), Update with Centering (Bittner 2009, 2011), and others. Some of these formalism are built to account for anaphora, in particular individual anaphora; others are built with mechanisms for the explicit representations of propositions, even if not considering the anaphoric potential thereof. For each system, I discuss what would need to be changed (if anything) in order to account for the data observed in Chapter 3. I then present a novel formal approach, taking insights from several of these existing systems, to account for the data presented here. I introduce the system with a few illustrative examples, using declarative sentences, sentential negation, embedding verbs, and relative clauses, and then discuss some issues around the compositionality of the system and describe what would be desirable in a successor to this system. Finally, I discuss the way this proposed system models the status of a propositions, which raises questions about the differing statuses that a proposition can have in a discourse model.

These questions about the status of a proposition, as it relates to its anaphoric potential, are the motivation for the final chapter. There is a growing body of literature investigating the effects of the discourse status of a proposition—in particular, its *at-issue* status. At-issueness has been associated with a proposition's truth-conditional contribution, with presupposition projection, and more (see Potts 2005; Tonhauser, Beaver, Roberts & Simons 2013, a.o.). Chapter 5 addresses the question *How does a proposition's availability for anaphoric reference interact with its at-issue status?* There is a presumption in the literature

that these two phenomena, though *a priori* distinct, are tightly linked; this is reflected both in the way at-issueness is diagnosed (Tonhauser 2012) and how it is modeled (Murray 2010, 2014; AnderBois, Brasoveanu & Henderson 2013), even as researchers debate how at-issueness should be defined. Focusing on the Simons, Tonhauser, Beaver & Roberts 2010 definition of at-issueness, I argue that these two phenomena are in fact distinct, and that one of the tests frequently used to diagnose at-issue status is in fact not diagnostic of at-issueness, but of anaphoric potential. If one instead uses the other two classes of diagnostics from Tonhauser 2012, which I argue are more reliable diagnostics for Simons et al. 2010 at-issueness, then the anaphoric availability of a proposition becomes differentiable from its at-issue status. As I demonstrate, at-issueness is neither necessary nor sufficient for a proposition to be available for anaphoric reference: I present examples of felicitous anaphora to not-at-issue propositions, as well as at-issue propositions which systematically fail to be available for propositional anaphora. I then discuss what this means for our theories of at-issueness and and how we model it.

Ultimately, this dissertation aims to provide (the beginnings of) a comprehensive and systematic examination of propositional anaphora. Up to this point, linguists and philosophers of language have been aware of the phenomenon, but there has not been an in-depth examination of how it works, and when. This dissertation aims to fill this gap. In doing so, I show that a careful examination of propositional anaphora also provides insights into the behavior of a wide range of linguistic phenomena, including: small clause embedding verbs; epistemic and root modals; sentential adverbs; the underlying structures of raising and control constructions; matrix and embedded interrogatives; and the nature of at-issueness.

CHAPTER 2

PROPOSITIONAL ANAPHORA IS ANAPHORA

2.1 Introduction

We use natural language (at least) to talk about topics. We introduce topics and comment on them. Sometimes, it is useful or desirable to continue discussing an already introduced topic, to comment on a topic that has already had been commented on. We might do this to further elaborate on a topic, adding new information, or to negotiate about comments that have already been made, perhaps seeking further information or even disagreeing with prior comments. In order to do this, we need a way to refer back to topics that have already been introduced. We can do this with *anaphora*, as in (3).

(3) Joan napped. She had been very tired.

We understand the meaning of the pronoun *she*, which is an *anaphor*, as referring back to the same individual as the one picked out by the name *Joan*.[1] *Joan* is the *antecedent* of the anaphor *she*. For ease of identification, the anaphors we'll be paying attention to will be italicized, with their respective antecedents underlined.

The phenomenon as a whole is called *anaphora*, from Ancient Greek *aná-* 'up, back' + *phérō* 'to carry'. In most cases, as in (4a), the anaphor follows its antecedent, forcing a hearer to recall back to a previously-mentioned entity (or, on a written page, to look *up*, higher on the page). When the anaphor precedes its antecedent, we call it *cataphoric* (from Ancient Greek *katá-* 'down'), as in (4b).[2]

[1] Chomsky 1981 uses the term *anaphor* so as to exclude pronouns, referring instead only to reflexives (e.g., *herself*) and reciprocals (e.g., *each other*). I will be using the term to refer to any word that gets its meaning from some other expression, including but not limited to pronouns.

[2] This *aná-* is cognate with English *on*, and is the same 'up' as in English *anatomy* (lit. 'cut up'). Meanwhile, *katá-* gives us English *catacomb*.

(4) a. Because Joan had been very tired, *she* napped.

b. Because *she* had been very tired, Joan napped.

Regardless of the ordering, both of the examples in (4) are considered to have an anaphoric relation between anaphor and antecedent.

These examples can be called *nominal anaphora*, in that the antecedent is introduced by a noun phrase (or a determiner phrase): this is a syntactic characterization. But (3) is perhaps better considered *individual anaphora*, in that the antecedent refers to an individual: this is a semantic characterization. We can use individual anaphora to refer to both singular and plural individuals (Link 1983), whether introduced by names (5a–5b), indefinite descriptions (5c), or quantifiers (5d–5e), as well as to fictional individuals (5f). And, lest we think of "individual" as referring just to humans, individual anaphora can able be used to refer to places (5g), objects (5h), kinds (5i), and abstract concepts (5j).

(5) a. Agatha Christie went to library. *She* started looking at biographies.

b. Kim and Jessie went to library. *They* started looking at biographies.

c. A woman went to library. *She* started looking at biographies.

d. Some women went to library. *They* started looking at biographies.

e. Every girl in the class went to library, and went straight for *her* favorite book.

f. Nancy Drew went to the library. *She* started looking at biographies.

g. Joan went to the library. *That* was her favorite place in town.

h. Joan's book was on the floor. She picked *it* up and put *it* back on the shelf.

i. The horse is indigenous to eastern Chile. *It* is a magnificent creature.

(cf. Carlson 1977)

j. At the academy, Fran learned love for her country. *It* shaped the course of her career.

We can also use anaphors to refer to *events*, the types of things denoted by verb phrases, as in (6), and to refer to *propositions*, which are denoted by (at least) declarative sentences, as in (7).

(6) Joan went to the library. She had been meaning to do *that* all week.

(7) Joan went to the library. She told me *that*.

Other processes in natural language have been argued to rely on similarly anaphoric relations, including the interpretation of tense (Partee 1973, 1984), modality (Stone 1997), response particles (Krifka 2013; Roelofsen & Farkas 2015), and discourse relations (Webber, Stone, Joshi & Knott 2003). Verb phrase ellipsis has also been argued to be an anaphoric process (Ginzburg & Sag 2000).

This dissertation focuses on propositional anaphora, as exemplified in (7).

In this first chapter, I introduce some background on anaphora (§2.2), and on propositions (§2.3), before turning to expressions of English which can refer anaphorically to propositions (§2.4). In §2.5, I demonstrate that propositional anaphora behaves in parallel to other domains, including individual, tense, and modal anaphora.

2.2 Anaphora

Anaphora is the phenomenon wherein the meaning of a linguistic expression, in particular in referring to an entity of some type, depends on the interpretation of some other linguistic expression. In a prototypical case like (3), repeated here, the anaphor *she* is understood as coreferential with the name *Joan*, its antecedent.

(3) Joan napped. She had been very tired.

The interpretation of *her* depends on our interpretation of *Joan*: the entity that *Joan* picks

out is the same one that *her* refers to.

This characterization of anaphora is imperfect, however (King & Lewis 2017). There are examples of anaphora which don't properly *refer*, such at the anaphor *her* in (5e). In this bound use, the anaphor doesn't pick out any individual, but instead covaries with the quantifier. In this sense, the interpretation of *her* depends on the interpretation of *every girl*, but the anaphor still doesn't refer. It's also not sufficiently precise to say that anaphora describes simply when the interpretation of one expression depends on the interpretation of another: such a definition would include disambiguation of lexically ambiguous words like *bank*, as in (8).

(8) John is down by the bank of the river. (King & Lewis 2017: (1))

The interpretation of the word *bank* here depends on the interpretation of the word *river*—so as to disambiguate it from the 'financial institution' meaning—but we wouldn't want to say that *bank* is *anaphoric* on *river*. Finally, the characterization above presumes that the antecedent, on which the interpretation of the anaphor depends, is a linguistic expression; as we will see in §2.5, this is too strict a definition.

Because of these issues, and because of the variety of types of objects which can be involved, anaphora can be difficult to define. In characterizing it, Webber et al. 2003 distinguishes three classes of anaphora: coreference, indirect anaphora, and lexically specified anaphora. Coreference includes the examples shown above, where an anaphor refers to the same entity as its antecedent.[3] This category includes "split reference", where a plural-marked anaphor picks up entities mentioned separately in the discourse, as in (9).

(9) Joan went to the library, and saw Marcia there. *They* hugged.

[3]On the Webber et al. 2003 classification, this presumably includes examples of bound anaphora like (5e), even though they don't properly refer.

Indirect anaphora describes cases where an anaphor picks up not a discourse referent, but rather an *associate* of a discourse referent, as in (10).

(10) Myra darted to *a phone* and picked up *the receiver*. (Webber et al. 2003: (25))[4]

The noun phrase *a phone* doesn't specifically introduce a discourse referent for the its receiver, but nonetheless the definite noun phrase *the receiver* is understood in (10) as referring to the phone's receiver. The term "indirect anaphora" comes from Hellman & Fraurud 1996, but this class has also been called bridging anaphora (Clark 1975; Clark & Marshall 1981; Not, Tovena & Zancanaro 1999), partial anaphora (Luperfoy 1992), textual ellipsis (Hahn, Markert & Strube 1996), associative anaphora (Cosse 1996), and inferrables (Prince 1992).

In the third class, lexically specified anaphora, an anaphor denotes a function which takes the antecedent (or an associate of the antecedent) as its argument, and returns a referent. Webber et al. 2003 provides (11) and (12) as examples (among others).

(11) I dont like sitting in this room. Can we move elsewhere? (Webber et al. 2003: (31))

(12) Sue lifted the receiver as Tom darted to *the other phone*. (Webber et al. 2003: (27))

In (11), *elsewhere* takes the place denoted by *this room* as its argument, referring to a (contextually restricted) complement set. In (12), *the other phone* refers to a phone distinct from the phone which is associated with *the receiver*. In addition to noun phrases with *other*, and the pronoun *elsewhere*, Webber et al. 2003 lists "NPs with *such* but no postmodifying *as* phrase" and "comparative NPs with no postmodifying *than* phrase" as other examples of lexically specified anaphora, following Bierner 2001. Webber et al. 2003 goes on to argue that discourse adverbials like *then*, *also*, *otherwise*, *nevertheless*, and *instead* also fall into this class of anaphora.

[4]Emphasis as in the original.

For the purposes of this dissertation, we'll be focusing on the first class of anaphora, coreference, wherein an anaphor simply refers to the entity picked out by the antecedent. Whether propositions have associates, or can be associates of other entities, in the way required for indirect anaphora remains an open question for future work.[5,6] It is also unclear whether there are lexically specified anaphoric expressions, parallel to *other*, which modify proposition-denoting expressions, such that this class generalizes across propositional anaphora as well.[7] For the meantime, we will focus on the simplest cases of propositional anaphora—the coreference class—to establish the groundwork for future exploration of these questions.

2.3 Propositions

This topic of this dissertation is anaphoric reference to propositions, but what is a proposition? Up to this point, I have merely asserted that propositions are things denoted by declarative sentences. In this section, I'll present some background on the role that propositions have in modern conceptions of natural language semantics, in particular as relates to the questions of anaphora that I will be pursuing here.

We have the intuition that speakers can use different words to convey the same meaning, that they can 'say the same thing'. For example, we have the sense that (13) and (14) mean the same thing (at least in the United States), despite the fact that they use different words.

[5]Webber et al. 2003 does not specify the limits of the `assoc` function, which takes an entity and returns the set of its associates, so it's not clear how it might interact with propositional discourse referents.

[6]We may need a type-shifting function between propositions and individuals, along the lines of Partee 1987; Ter Meulen 1995, to account for sentences like (i).

(i) Joan napped. *That fact* pleased Ernest.

The definite NP *that fact* denotes an individual, and is anaphoric on the first sentence, *Joan napped*, which denotes a proposition. While these phrases denote objects of different types, they still pick out the same entity (the proposition 'Joan napped'), so this is likely distinct from the `assoc` function needed to resolve Webber et al.'s (2003) indirect anaphora. This is coreference, albeit across types.

[7]These types of modifiers can certainly combine with individual-denoting expressions which can then be type-shifted to propositions, such as *the other belief*, but this is still individual-denoting.

(13) [Claire's mother:] My daughter is an attorney.

(14) [Claire's daughter:] My mom is a lawyer.

What's more, we have the sense that (15) means the same thing as (13) and (14), even though it is in a different language entirely (namely Spanish).

(15) [Claire's mother:] Mi hija es abogada.

We can capture these intuitions by making use of the notion of a proposition: these sentences mean the same thing, even though they use different words (in different languages), because they *express the same proposition*. Propositions are simply the truth-conditions of declarative sentences, or as Perry 1993 quotes Frege, "that for which truth arises": we understand a sentence (no matter which words are used) when we identify the proposition associated with it.

And just as we use propositions to capture sameness across sentences and languages, we can also use propositions to capture sameness of belief and other attitudes: if two people share the same belief, it is not in virtue of any linguistic object (e.g., a sentence) that they do so, but rather because they stand in the same relation to the same proposition.[8] As a result, we say that *that*-clauses, the sorts of things embedded under attitude verbs in English, denote propositions. Propositions are also useful for representing modal statements: it is not a linguistic object which is described by *necessary* or *possible*, but a proposition. Linguists and philosophers of language continue to debate the role of propositions in interrogative and imperative sentences, but at least for Stalnaker 1976: 79, the role of propositions is not restricted to declarative sentences: "Propositions are things people express when they make predictions or promises, give orders or advice. They are

[8] In defending a possible world semantics as a way to capture propositions, Stalnaker 1976: 82 says: "If desires and beliefs are to be understood in terms of their role in the rational determination of action, then their objects have nothing essential to do with language. It is conceivable (whether or not it is true) that there are rational creatures who have beliefs and desires, but who do not use language, and who have no internal representations of their attitudes which have a linguistic form."

also things people doubt, assume, believe to be very likely, and hope are true."

While sharing this central idea of the function of propositions, people have disagreed about how best to understand them. In a possible worlds semantics, a proposition denoted by a sentence is a set of worlds: the worlds which make the sentence true (see Lewis 1970; Montague 1970; Stalnaker 1976, among others). If worlds are fully-settled maximally-determined states of affairs, then this notion of a proposition can run aground of issues related to identity[9] and logical omniscience.[10] To avoid these issues, some researchers adopt accounts of propositions which allow for more fine-grained distinctions than just reference to possible worlds. This has been handled in different ways, including Russellian structured propositions, which have internal structure that includes individuals and the relations that hold among them (see Barwise & Perry 1981; Soames 1987, among others). For more detailed reviews of the different views on propositions, see Hanks 2009; King 2017. Ultimately, presuming that we adopt some system that can differentiate between propositions that are true at the same worlds (whether along the lines of Barwise & Perry 1981 or Cresswell 1985), the differences between these different conceptions of propositions will not bear on the questions about anaphora I will address here.

There are researchers who make finer distinctions among the types of things I will be considering propositions here. For example, Peterson 1982 and Parsons 1993 distinguish *facts* as a distinct category from propositions, on the basis of predicates which seem to take one but not the other. Peterson's (1982) typology is in (16–17), and Parsons's (1993) examples in (18).

[9]Because sets are defined by their members, the proposition 'Superman can fly' is indistinguishable from the proposition 'Clark Kent can fly', even though it's easy to imagine someone who might recognize one proposition as true while disbelieving the other.

[10]If mathematical truths like '$2 + 2 = 4$' and '8675309 is prime' are true at all possible worlds, then how is it that rational agents can fail to know the truth value of certain statements of mathematics?

(16) Predicates of facts

-matters, -amuses, -explains, -surprises, realizes-, remembers-, discovers-, knows-, hears-, -tragic, -important, -significant, -crazy, -odd, -mysterious, -result, -fact, -explanation, -consequence, -reason, -upshot, etc. (Peterson 1982: (7))

(17) Predicates of propositions

believes-, fears-, hopes-, wants-, thinks-, affirms-, denies-, -(un)likely, -(im)possible, -(in)consistent, -seems strange, -appears important, -sure, -true, -certain, -proposal, -hypothesis, etc. (Peterson 1982: (9))

(18) a. * She believes everything her mother regrets.

b. * She says everything that is tragic.

c. * Whatever amuses him is likely. (Parsons 1993: 455)

Some of these classifications simply seem erroneous, like *amuse* or *tragic*, which can take both individual and event arguments, as in (19) and (20) respectively.

(19) a. Magnus's sideburns are bushy.

b. Magnus's sideburns amuse me.

c. Magnus's sideburns are tragic.

(20) a. The destruction of the city lasted three days.

b. The destruction of the city amused Nero.

c. The destruction of the city was tragic.

Moreover, that Peterson 1982 classifies *true* as a predicate of propositions—and not of facts—should raise concerns. After all, the central distinction between propositions and fact, on this line of reasoning, is the truth of the latter.

> "'Facts, facts, facts' cries the scientist if he wants to bring home the necessity of a firm foundation for science. What is a fact? A fact is a thought that is true."
> (Frege 1918: 307)

In other words, facts are just propositions which are (thought to be) true in a world. But that is not a reason to consider them distinct entities; rather facts are a subset of propositions, namely the true ones. We can distinguish between individuals which are dogs and individuals which are not dogs, and the predicate *Border Collie* will apply only to individuals of the former type. But that alone is not reason to distinguish dogs type-theoretically from individuals; dogs are merely a subset of individuals.

Similarly, Asher 1993 distinguishes both facts and *possibilities* as distinct types of entities from propositions. For Asher 1993, the distinction is on the basis of the "extended Vendlerian argument" (31), which considers which predicates are compatible with different noun phrases which take *that*-clause complements (in the spirit of Vendler 1957). For example, Asher 1993 argues on the basis of (21) that *announce* "may be satisfied by facts but not by thoughts or propositions", and thus that facts and propositions are distinct.

(21) a. John announced the fact that he was married.

b. # John announced the thought (claim) that he was married.

(Asher 1993: 31: (45))

Similarly, Asher 1993 argues on the basis of *fear* in (22) that possibilities are distinct from both facts and propositions.

(22) a. John feared the possibility that Mary had left without him.

b. ? John feared the claim that Mary had left without him.

c. John believed the claim that Mary had left without him.

d. ? John believed the possibility that Mary had left without him.

e. ? John feared the fact that Mary had left without him.

(Asher 1993: 31: (46–47))

But this style of argument is about head nouns, not about the types of their arguments.

On this approach, one would further have to distinguish, say, *suspicions* as a privileged type of entity: *suspicion* is incompatible with *announce*, as in (23a), and so doesn't denote a fact; it is incompatible with *believe*, as in (23b), and so doesn't denote a proposition; and it is incompatible with *fear*, as in (23c), and so doesn't denote a possibility.

(23) a. # John announced the suspicion that he was married.

b. # John believed the suspicion that Mary had left without him.

c. # John feared the suspicion that Mary had left without him.

For the purposes of this dissertation, I will treat all of these things as one type of entity: propositions. As Hanks 2009 points out, sentences like those in (24), which make use of *believe*, *know*, and *fear*, suggest that these predicates all relate to entities of the same type.[11]

(24) a. Everything Andy believes, Jon knows.

b. Andy fears something that Jon knows.

I will call that type a proposition, and examine its anaphoric properties.

This is not to say that we can't use predicates to diagnose the type of an argument. On the contrary, I'll be using that method extensively, to distinguish propositions from events and individuals (though not from facts or possibilities, which I've argued above are subtypes of propositions). For the purposes of this work, I take it as given that having a truth value is a property of propositions (and not events), as is being known, believed, and many properties introduced by attitude verbs. Events, unlike individuals and propositions, occur at a particular time and place, and therefore can be arguments of certain predicates of time and space. Individuals similarly have their own predicates. For example, consider the triplets in (25–27):

[11]See also King 2002 on how these different predicates can interact and how to explain substitution failures without resorting to additional types.

(25) a. John is tall.

b. # John's skateboarding is tall.

c. # That John went skateboarding is tall.

(26) a. # John took place this morning.

b. John's skateboarding took place this morning.

c. # That John went skateboarding took place this morning.

(27) a. # John is true.

b. # John's skateboarding is true.

c. That John went skateboarding is true.

The predicate *tall* exemplifies a class of predicates which take individuals—but not events or propositions—as arguments, as in (25). *Take place*, meanwhile, describes events, but not individuals or propositions, as they don't have 'runtimes', as in (26).[12] And, finally, as desired, *true* is compatible with propositional arguments, but not with individuals or events, as in (27). These sorts of predicates will be useful diagnostics for determining what type of argument a construction denotes. Some such predicates can be tricky, as they appear to take other types as argument as well, either by lexical ambiguity[13] or by coercion,[14] but we'll avoiding such confounds whenever possible.

Before concluding, it's worth discussing the type-logical type of a proposition. On a

[12]Individuals might have lifespans, but these times seem to be distinct from event runtimes, as a sentence like (ii) is ungrammatical.

(ii) * Catherine the Great took place from 1729 to 1796.

[13]For example, *know* can take an individual as an argument if it is used in the sense of 'be familiar with'. These two meanings are distinct, and are lexicalized as different words in many other languages: it's merely a quirk of English that they're homophonous.

[14]For example, *was yesterday* can take an individual as an argument if we understand some additional predicate to have been elided. In certain contexts, one might take (iii) to mean that Carmen's scheduled time, e.g. for giving a presentation, was yesterday.

(iii) Carmen was yesterday.

This isn't about Carmen having occurred at a particular time, but about understanding the name *Carmen* to pick out some salient event (as only events, not individuals or propositions, occur at times).

simple possible worlds model, a proposition is a set of worlds, and so is type $\langle s, t\rangle$. This is the type usually assigned to propositions, despite sets of worlds not being sufficient for proposition individuation: it acts as a sort of shorthand for 'sets of worlds, or whatever appropriately fine-grained alternative replaces them'. For the most part, I will adopt this convention as well.

Throughout, I will use the term "proposition" to mean not just maximally-specified situations, but to include open propositions as well. An open proposition is a proposition with one or more arguments filled by an unbound variable, and we'll need them in order to account for examples like (28) and (29).

(28) Jasmine is a scholar, and *that* is true of Kendra as well.

(29) Daniel is an honest person today, and *that* was true yesterday as well.

In (28), the proposition which is true of Kendra must be 'x is a scholar'—an open proposition—rather than 'Jasmine is a scholar', which cannot be true of Kendra. The subject position is left 'open' from the proposition described by the first clause. A parallel thing happens in (29), except with a temporal variable. The proposition which is asserted to be true of the time picked out by *yesterday* is 'Daniel is an honest person at time t'. In both of these cases, the anaphor *that* seems to pick out not a fully-specified proposition but an open proposition.[15] I leave aside for now the question of whether these are always open, or whether they are created by an abstraction procedure.

There is one point worth mentioning here regarding the way propositions compose with attitude verbs. Propositions are the sorts of things which attitudes (like belief) are about, so the straightforward assumption would be that verbs like *believe* take arguments of type $\langle s, t\rangle$ for the target of the attitude (in addition to a type e argument for the attitude-

[15] At least for (28), this open proposition appears suspiciously similar to a *property*. However, the objects we are interested in here can be described by *true* and *false*, and are things that can be known or doubted or believed; these sorts of descriptions appear suitable in talk of propositions, but not talk of properties.

holder). On a Kratzer 2006 account, though, attitude verbs like *believe* take *two* arguments of type e: the attitude-holder, and an individual which conveys propositional content. Moulton 2015: 310 argues that both *that*-clauses and content nouns like *myth*, *story*, and *rumor* "denote properties of individuals that carry propositional content (type $\langle e, st\rangle$)", and so can combine together via Predicate Modification, and can be taken (together or individually) by verbs like *believe*. To achieve this, Moulton 2015 has the complementizer *that* take a proposition and return the set of individuals which carry that proposition's content. For the purposes of this dissertation, I'll be talking about *that*-clauses (including as complements of attitude verbs or content nouns) as denoting propositions, because these type differences won't be directly relevant for the anaphora facts I'm interested in. Whether *that*-clauses directly denote propositions—type $\langle s, t\rangle$—, or whether they denote properties (of entities that carry propositional content)—type $\langle e, \langle s, t\rangle\rangle$ (Moulton 2015) or type $\langle e, t\rangle$ (Elliott forthcoming)[16]—with the proposition itself as the argument of the complementizer, either way a proposition is encoded in the derivation of the clause. And it is the anaphoric properties of that proposition which I will be examining here.

2.4 Anaphors

In this section, I'll review the English words which can function as propositional anaphors. In particular, these are the demonstratives *this* and *that*, the proform *that*, the relative pronoun *which*, and the coordinators *as* and *so*. I'll also look at null compelement anaphora, where there is no explicit anaphor but where reference is nevertheless made to an antecedent proposition. There are interesting questions about the inventory of propositional anaphors across languages, and it is by no means a given that the English set is paradigmatic; those questions will remain for future work, however.

[16]See Elliott forthcoming for more on the semantics of *that*-clauses, and for a syntactic distinction to be made between classes of DPs, those which (can) host propositional content and those which cannot.

2.4.1 The demonstratives *this* and *that*

We normally think of demonstratives (like *this* and *that*) as picking out an individual or some other entity which is made salient in the context, usually by nonlinguistic means.

(30) [After unlocking the door, Xander leads a friend into his apartment.]
Well, *this* is my place.

(31) [Kay finds her favorite guitar pick in her jacket pocket.]
I was wondering where *this* went.

(32) [At a school soccer game, Christina points at a child who's just scored.]
That's my son!

(33) [Cedric sees Kelly reading a rare first edition Austen novel.]
I can't imagine where she found *that*.

In (30), the anaphor *this* refers to the place that has been raised to salience by being newly available to the interlocutors. In (31), *this* refers to Kay's guitar pick, raised to salience by having just been found. In (32), the anaphor *that* refers to the child who had just made himself relatively salient by scoring a goal. In (33), *that* refers to the rare Austen novel which Cedric sees Kelly reading, salient (at least to Cedric) due to its rarity.

In addition to picking out salient individuals in the context, English uses its singular demonstratives to anaphorically refer to propositional discourse referents.

(34) A: Did you hear? Kyle won the race!

B: a. *This* I know.

b. I know *this*.

c. *That* I know.

d. I know that.

The plural demonstratives *these* and *those*, however, cannot be used as propositional anaphors; contrast (34) with (35).

(35) A: Did you hear? Kyle won the race!

B: a. # *These* I know.

b. # I know *these*.

c. # *Those* I know.

d. # I know *those*.

Even when there are multiple propositions being discussed, as in (36), the plural demonstratives are infelicitous.

(36) [Farah challenges Jeremy and Stu to tell her something about whales that she doesn't already know.]

Jeremy: Blue whales are pregnant for 10–12 months.

Stu: You can tell how old a whale is by counting the rings in its earwax.

Farah: a. # *These* I know.

b. # I know *these*.

c. # *Those* I know.

d. # I know *those*.

These plural demonstratives can be felicitous in this context with some help, as in (2.4.1), but the addition of *are things* indicate that we're no longer dealing with propositional anaphora; instead, this is individual anaphora, with *things* (or, equally, *facts*) performing an 'individuating' function, that is, giving us individual-type arguments.[17]

[17]These are individuals with propositional content; see Moulton 2015 and discussion in the previous section.

(36′) Farah:
a. *These* are things I know.
b. I know *these* things.
c. *Those* are things I know.
d. I know *those* things.

The singular *this* and *that*, though, remain felicitous even when referring to (plural complexes of) multiple propositions, as in (37).

(37) [Farah challenges Jeremy and Stu to tell her something about whales that she doesn't already know.]
Jeremy: Blue whales are pregnant for 10–12 months.
Stu: You can tell how old a whale is by counting the rings in its earwax.
Farah:
a. *This* I know.
b. I know *this*.
c. *That* I know.
d. I know *that*.

Up to this point, I have discussed the demonstratives *this* and *that* as though they were monolithic; and, indeed, they have been described as such: Webber 1988 argues that the two are interchangeable, differing only in a speaker's "psychological distance" to the referent. However, the two demonstratives do differ in use. In particular, the proximal *this* allows for cataphoric uses—that is, forward-looking reference to antecedents not yet introduced—where the distal *that* does not. Consider the utterances in the context of (38).

(38) [Discussing who was at the party last week; Erik hasn't yet been mentioned.]

a. i. *This* is what I was told: Erik was there.

ii. # *That* is what I was told: Erik was there.

b. i. I was told *this*: Erik was there.

ii. # I was told *that*: Erik was there.

c. i. Erik was there. *This* is what I was told (by Joanna).

ii. Erik was there. *That* is what I was told (by Joanna).

d. i. Erik was there. I was told *this* (by Joanna).

ii. Erik was there. I was told *that* (by Joanna).

The examples in (38a)–(38b) are cataphoric, in that the antecedent—*Erik was there*—is not yet introduced at the time the anaphor is uttered. In these cases, *this* is acceptable, but *that* leads the sentences to be judged as infelicitous. The sentences in (38c)–(38d), on the other hand, are anaphoric (in the strict arrangement sense) in that the antecedent occurs before the anaphor (here, a demonstrative) doing the referring. In these cases, both *this* and *that* are acceptable. So where *this* can be used for both anaphoric and cataphoric uses, *that* is strictly for anaphoric—that is, backwards-looking—use.

One way that we can understand this distinction is by looking at how people tend to use *this* and *that*, even in contexts where both would perhaps be licit. Lord & Dahlgren 1997 found that the proximal *this* is more often used to refer to discourse referents[18] which are considered topical to a discourse, where *that* is more often used with discourse referents which are considered peripheral. If this generalizes, then we might explain the behavior in (38) as a consequence of the more peripheral nature of *that*, which as a result cannot be used to introduce new topics into the discourse. That said, Lord & Dahlgren

[18]Lord & Dahlgren 1997 looks at anaphora to all types of discourse referents, including individuals, events (both eventive and stative), and propositions.

1997 suggests that those results may be genre-dependent, so there may be more work needed in order to explain the incompatibility of *that* with cataphoric uses.

It seems, then, that the proximal demonstrative, *this*, is in some sense the more general 'all-purpose' anaphor of the two demonstratives, where the distal *that* is reserved for truly *anaphoric* anaphoric uses. Given this all-purpose/specific dichotomy, we might expect that for some speakers the anaphoric (in the spatial sense) use of *this* would be somewhat marked (although still acceptable), considering that the word *that* is equally available and more specific to the task as a possible competitor; and this is precisely the case. Some speakers prefer (38cii) over (38ci), and (38dii) over (38di), for example. This is in line with a 'competition of forms' story for words which are otherwise interchangeable, as they are in a backward-looking anaphoric use.

2.4.2 The proform *it*

The proform *it* is typically used as a pronoun, to refer to a non-human individual, as in (39).

(39) a. Have you seen my wallet? I can't find *it* anywhere.

b. Felicia loves Central Park. *It*'s her favorite place in the world.

It is also frequently used in expletive constructions, as in (40).

(40) a. It's my birthday today.

b. It seems likely to rain.

But *it* is not limited to referring to individuals: *It* can also be used to refer to events (Bresnan 1971; Postal 1972; Hankamer & Sag 1976), as in (41–42), and to propositions (Webber 1991; Asher 1993; Gundel et al. 2003; Needham 2012), as in (43–44).

(41) Jack didn't cut Betty with a knife—Bill did *it*. (cf. Hankamer & Sag 1976: (30))

(42) Jack didn't get picked off by a throw to first, but *it* happened to Bill.
(cf. Hankamer & Sag 1976: (31))

(43) John believes that [Mary is a genius]$_i$. Fred is certain of it$_i$. (Asher 1993: 241: (23))

(44) Felicia says Central Park is her favorite place in the world, but I doubt *it*.

On a Moulton 2015 style account, (43–44) might also be considered to be reference to individuals: individuals that bear propositional content. Nevertheless, the predicates *certain* and *doubt* indicate that it is the propositional content which the anaphor makes available, so this is a different sort of anaphoric use from that of (39).

There are differences between where *it* and the demonstratives *this* and *that* appear. In particular, researchers have noted that the demonstratives are used more often than *it* (Webber 1988, 1991), and that substituting *it* in place of *this* or *that* frequently leads to infelicity, or otherwise changes the interpretation of the sentence (Gundel et al. 2003). For example, consider the examples in (45) and (46).[19]

(45) a. Erik was at the party. Joanna told me *that*.

b. ?? Erik was at the party. Joanna told me *it*.

(46) A: You have a dental appointment at 2.

B: That's true.

B′: ?? It's true.

B″: It's true, then. (Gundel et al. 2003: (18))

One can explain at least some of this behavior by noting that *it* is a weak pronoun—in the sense of Cardinaletti & Starke 1999—and thus is syntactically restricted from occurring

[19]Judgment marks in (46) as in the original; see discussion of these judgments, and the role of *then*, in Gundel et al. 2003.

in certain positions: θ-positions, coordination structures, "peripheral" positions, etc. In contrast, *this* and *that* are strong pronouns, and are subject to different restrictions.

Gundel et al. 2003 argues that the differences between *it* and the demonstratives are a consequence of a requirement that the referent of *it* "be in focus whereas demonstrative pronouns *this/that* only require activation" (using the Givenness Hierarchy; Gundel, Hedberg & Zacharski 1993). Needham 2012 analyzes this use of *it* as a propositional pro-form which presupposes that the antecedent is a commitment of the speaker, which is presumably not also a requirement of the demonstratives *this* and *that* in their use as propositional anaphors. This presupposition, then, might also account for some of the cases where *it* is disallowed; this alone is not sufficient to explain the behavior in (46), though, as the dental appointment is clearly a commitment of the speaker.

It also cannot be used cataphorically, like *that* but unlike *this*.

(47) a. # *It* is what I was told: Erik was there.

b. # I was told *it*: Erik was there.

(48) a. # *It* is what I believe: Erik was there.

b. # I believe *it*: Erik was there.

I include (48) in addition to (47), in case part of the restriction on (47) is due to *it*'s incompatability with *tell* in general (despite constructions like *Tell it to the jury!*). The cataphoric behavior of *it* might also be explained as a function of a givenness requirement, but there may be other explanations of this behavior as well; I leave this question to future work.

2.4.3 The relative pronoun *which*

The relative pronoun *which* can also be used to refer anaphorically to a propositional referent. Even though relative clauses are frequently discussed in their uses modifying

noun phrases—describing individuals—, as in (49), they can also modify clauses—and thus describe propositions—, as in (50)–(51) (see Jackendoff 1977; Fabb 1990; Arnold 2004; Arnold & Borsley 2008).

(49) Tracy saw the book, *which* Derek had bought the day before, lying on the table.

(50) Tracy wanted the book, *which* Derek knew.

(51) Tracy thought it was left there accidentally, *which* wasn't the case.

Relative constructions are usually characterized by their syntactic nature (classified as internally-headed, externally-headed, or correlative) and by their semantic effect (classified as restrictive or non-restrictive), though many of these divisions presume a nominal antecedent rather than a propositional one. For example, classifying a relative clause as restrictive or non-restrictive presumes that we're dealing with a set of individuals (described by a noun phrase) which can be restricted (as in (52)) or not (as in (53)). (For comparison, prepositional phrases are normally restrictive; (53) has the same interpretation as (54).)

(52) The dog, which has floppy ears, is Greta's. NON-RESTRICTIVE RELATIVE CLAUSE

(53) The dog which has floppy ears is Greta's. RESTRICTIVE RELATIVE CLAUSE

(54) The dog with floppy ears is Greta's. RESTRICTIVE PREPOSITIONAL PHRASE

The relative clause in (52) doesn't help to pick out a particular dog—it doesn't restrict the set of dogs we're considering—, it instead provides some additional information about that dog (which we've already identified). The relative clause in (53), in contrast, does help us to identify which dog is being discussed; (53) can be uttered in a context in which there are multiple salient dogs, as long as only one has floppy ears. In contrast, (52) is only felicitous in a context in which there's only a single salient dog, floppy eared or otherwise.

The restrictive/non-restrictive distinction doesn't properly apply to relative clauses which modify non-nominals, as all such relative clauses are non-restrictive: "while RRCs [(restrictive relative clauses)] are always nominal modifiers, NRCs [(non-restrictive relative clauses)] take a much wider range of antecedents:" (Arnold 2004: 29). Descriptively speaking, we don't see sentences like (50) that have the syntax and prosodic character of the RRC in (53). It's not entirely clear, however, whether this is a fact about the syntax (or prosody) of clause-modifying relatives, or due to a difference between the way we refer to propositions as opposed to individuals. Functionally speaking, it seems as though knowing about the properties that hold of a proposition (e.g., that Derek knows it) don't help to identify it, i.e., to narrow down the set of potentially intended referents; this stands in sharp contrast to the individual domain, where knowing about a property (e.g., having floppy ears) is precisely what allows us to identify it. Continuing the thought, this might indicate that while speakers consider and negotiate ambiguities about which individuals are denoted by a nominal expression, they don't do the same for which proposition is denoted by a clause. Why precisely this should be the case remains to be explained. Nevertheless, it seems that clausal relatives are all non-restrictive, to the extent that this classification is applicable in the propositional domain.

The syntactic classifications are even harder to fit propositional relative clauses into. Where the semantic classification has an 'elsewhere' case in the non-restrictive class, the definitions of the various syntactic classes assume a noun. The World Atlas of Language Structures definition of relative clauses is general enough to allow for non-nominal cases—"A construction is considered a relative clause for the purposes of this map if it is a clause which, either alone or in combination with a noun, denotes something and if the thing denoted has a semantic role within the relative clause." (Dryer 2013: Ch. 90)—but none of the examples given have a clause "alone" (not "in combination with a noun"), and all of the later more specific definitions presume a nominal relative: "The two basic types shown on Map 90A are languages in which the relative clause follows the **noun**,

and languages in which the relative clause precedes the **noun**" (emphasis mine). WALS is not alone in this: Keenan 1985 defines relative clauses as "a clause which describes the referent of a head noun or pronoun", and in doing so restricts the definitions of externally-headed and internally-headed relative clauses to only nominal ones. The third major class of relative clauses, correlatives, are also only discussed as relating to nominals: Dryer 2013 describes them as "a subtype of internally-headed relative clauses in that the head **noun** occurs inside the clause" and whose "relative clause is outside the main clause and is connected anaphorically to a **noun phrase** in the main clause that corresponds to the head **noun** in the English translations" (again, my emphasis). Lipták 2009 defines correlatives as "a left-peripheral relative clause [which] is linked to a (possibly phonetically unrealized) **nominal** correlate in the clause that follows the relative clause" (my emphasis).[20]

If we did want to categorize the propositional relative clauses in (50)–(51) as belonging to one of these syntactic subtypes, we'd have to say that they're externally-headed relative clauses, if only because the anaphoric antecedent—the proposition—isn't encoded by any content within the relative clause. That said, the typology falls apart somewhat, as it's not entirely clear what the head of a propositional relative clause would be in the first place. Is the entire matrix TP the head? The CP?

Like *that*, and like other relative pronouns broadly, the relative pronoun *which* does not function cataphorically, as in (56); it can only refer to discourse referents introduced previously in the discourse, and indeed, immediately beforehand (whether by the same speaker, as in (55), or a different speaker, as in (57)).

(55) Erik was there, *which* is what I was told.

(56) * *Which* was what I was told, Erik was there.

[20]With the exception of accounts that analyze conditionals as a special kind of correlative clauses (Bhatt & Pancheva 2006; Arsenijević 2009), there's not much discussion of sentences like (50) with propositional antecedents are correlatives. Correlatives seem to explicitly and exclusively deal with nominal antecedents, so they won't be of use to us in the analysis of propositional relatives.

(57) A: Erik was there.

B: *Which* is what I've been trying to tell you!

The relative pronoun *which* is also involved in structures which have been called "gapless relative clauses", as discussed in Collins & Radford 2015 (and references therein). These are reported as marginal by many speakers, but can be found in corpora, and appear to modify both individuals (as in (58)) and propositions (as in (59)).

(58) Theres also the stunning crash on the Tour de France, *which* I watched the highlights last night and I was amazed at what happened.

(Adrian Durham, Talk Sport Radio, cited in Collins & Radford 2015: (4g))

(59) And she decided to move out, *which* I think she's crazy.

(Loock 2007, cited in Collins & Radford 2015: (3c))

On some accounts, this *which* is simply a connective, and is not anaphoric in any sense (Loock 2007), but Collins & Radford 2015 argues that this is still a normal (anaphoric) relative pronoun, albeit with content which has been deleted. See Collins & Radford 2015 for discussion.

2.4.4 The coordinators *so* & *as*

Both *so* and *as* have many different uses in English, though their ranges of meaning overlap a great deal, which is why I'll address them both together, highlighting their similarities and differences along the way. Some uses of *so* and *as* are best analyzed as coordinators, as in (60)–(62).[21] In these cases, both *so* and *as* coordinate two clauses and say something about their temporal ordering. In a sentence like ϕ *so* ψ, the coordinator

[21] I use the term *coordinator* loosely here: I don't mean to assert that these are in the head of &P. English-teaching texts frequently describe *so* as a coordinating conjunction and *as* as a subordinating conjunction, even though both can be taken to introduce temporal information (as in (60)–(62)). At least for the *so*'s and *as*'s which introduce adjunct CPs—like purpose clause *so* or temporal clause *as*—these are likely not coordinators in the &P sense.

so conveys a causal relationship of ψ on ϕ. Given what we know about the universe, this also means that the event described by ϕ temporally precedes the event described by ψ. *as*, on the other hand, can be interpreted as coordinating events which are overlapping, or as conveying a causal relation opposite that of *so*, with ϕ *as* ψ meaning that ϕ is a consequence of (and thus temporally follows) ψ.

(60) Owen went to the mall(,) **so** Betty went home.

≡ Owen went to the mall, therefore Betty went home.

$$\tau(go.mall(\mathtt{o})) < \tau(go.home(\mathtt{b}))$$[22,23]

(61) Owen went to the mall **as** Betty went home.

≡ Owen went to the mall while Betty went home.

$$\tau(go.mall(\mathtt{o})) \cap \tau(go.home(\mathtt{b})) \neq \emptyset$$

(62) Owen went to the mall, **as** Betty went home.

≡ Owen went to the mall because Betty went home.

$$\tau(go.mall(\mathtt{o})) > \tau(go.home(\mathtt{b}))$$

In (60), we understand Betty's behavior as following Owen's, likely as a consequence (be it direct or indirect), where in (61) and (62)—differentiated only by an intonational break, noted here with a comma—we understand Betty's going home as occurring at the same time or prior to Owen's going to the mall (respectively). The *as*- and *so*-clauses which are coordinated in this way can also be sentence-initial, as in (63–65), though some of these readings are easier to get when combining events which are stative or otherwise explicitly occur over longer periods of time.

In the non-fronted cases (60)–(62), these might occur in the head of C, as they do not allow the inclusion of the complementizer *that*. The same can't be said (at least) for the purpose clause *so* in (63), however, which is perfectly grammatical with *that*.

(iv) So that Owen would remember to go to the mall, Betty left a note.

This suggests that there is indeed a syntactic distinction between coordinating *so* and subordinating *as*.

[22]Take τ to be a function from events to times, locating the time (interval) of the event, which can then be compared with other times.

[23]Whether the relationship asserted by *so* should be taken as purely the temporal ordering of events (with the casual inference as an implicature thereof) or as the casual relationship (with the temporal ordering an entailment thereof) is an interesting question, but one which is beyond the scope of the current project.

(63) **So** Owen would remember to go to the mall, Betty left a note.

(64) **As** Owen was arriving at the mall, Betty was heading home.

(65) **As** Owen had arrived at the mall, Betty decided to go home.

The clause introduced by *so* in (63) is a purpose clause, so it is only felicitous with an irrealis reading (expressed in subjunctive mood); contrast with (63′), which is ungrammatical on the same purposive reading.

(63′) * So Owen went to the mall, Betty left a note.

Other uses of *so* and *as* deal with degrees, as in (66–71). In some of these contexts, *so* and *as* are interchangeable, as in (66–67). In some other cases, though, *so* acts as something like an excessive, as in (68), or an emphatic, as in (69), where *as* does not. In other cases, *as* acts as an equative, as in (70–71), where *so* cannot. (Because the demonstratives can also make reference to contextual standards of comparison—and because the similarities and difference between the demonstratives and *as* and *so* are of interest in this context—I provide the demonstratives alongside them as well.)

(66) a. Owen was never **so** happy when he was at home.

b. Oven was never **as** happy when he was at home.

c. Oven was never {**this/that**} happy when he was at home.

(67) a. Owen was never **so** happy as he was when he was at the mall.

b. Oven was never **as** happy as he was when he was at the mall.

c. * Oven was never {**this/that**} happy as he was when he was at the mall.

(68) a. * Owen went to the mall **as** much that Betty couldn't stand it.

b. Owen went to the mall **so** much that Betty couldn't stand it.

c. * Owen went to the mall {**this/that**} much that Betty couldn't stand it.

(69) a. * Owen went to the mall **as** much!

b. Owen went to the mall **so** much!

c. Owen went to the mall {**this/that**} much!

(70) a. Owen was as happy as a clam.

b. # Owen was so happy as a clam.[24]

c. # Owen was {**this/that**} happy as a clam.[25]

(71) a. Owen went to the mall **as** much as Betty could stand.

b. * Owen went to the mall **so** much as Betty could stand.

c. * Owen went to the mall {**this/that**} much as Betty could stand.

One could argue that there is a semantic core common to these uses, connecting the degree-relating and event time-relating uses of *so* and *as*, but such a project is beyond the scope of the current enterprise.

so and *as* can also act anaphorically, referring to events, as in (72) (see also Cornish 1992; Gast & König 2008).

(72) a. Owen went to the mall, and Betty did *so*, too.

b. Owen went to the mall, *as* did Betty.

In comparing the anaphoric uses of *so* and *it*, Cornish 1992 argues that the *did so* construction, as in (72a), is an anaphoric use, in contrast to the *so did* construction, as in (73).

(73) Owen went to the mall, and **so** did Betty.

The latter, (Cornish 1992: 165) argues is a "variant form of *also*".

[24]This is felicitous with an emphatic *so*, but not as an equative.

[25]This is felicitous with a contextual standard of happiness c, on a reading where Owen was as happy as c at the time that he was a clam. This reading is also available for (70a). This sentence is infelicitous on a purely equative reading, however, where Owen was never himself a clam.

Finally, we turn to the examples that are most relevant to the current project, where *so* and *as* are used to refer anaphorically to a proposition, as in (74).

(74) a. Owen went to the mall. I know *so*, because I saw him there.

b. Owen went to the mall, *as* is known.

There has been some work on *so* as a propositional anaphor going back to Ross 1972; Hankamer & Sag 1976, and more recently, in particular in responses to polar questions (Gast & König 2008; Sailor 2012; Needham 2012; Meijer in press). (I am not aware of any equivalent work on *as*.) Needham 2012 argues that *so* is a propositional anaphor which picks out the propositional content of the current Question Under Discussion (Roberts 1996), presupposing uncertainty with respect to that proposition on the part of the speaker. Meijer in press argues that *so* isn't a simple propositional anaphor of type $\langle s, t \rangle$, but instead is an anaphoric adverb. If *so* were of type $\langle s, t \rangle$, then it would have to be the argument of a covert complementizer in order to combine with predicates like *believe* (on the Kratzer-Moulton approach). But *so*, unlike *that*-clauses with a covert complementizer, *can* be topicalized, as in (75) in contrast to (76a), and *cannot* be the complement of content nouns, as in (77c).

(75) A: My father gave his life so that we may have a chance to defeat this.

B: So you've told us. (Star Wars Rogue One, quoted in Meijer in press)

(76) a. * [$_{CP}$ C [$_{IP}$ John likes Mary]] Jane didn't believe.

(Bošković & Lasnik 2003: (3e))

b. [$_{CP}$ That [$_{IP}$ John likes Mary]] Jane didn't believe.

(Bošković & Lasnik 2003: (4e))

(77) a. I believe/claim/am afraid so.

b. my belief/claim/fear that pigs fly

c. * my belief/claim/fear so (Moulton 2015: (6))

Instead, Meijer in press argues that *so* is an anaphoric adverb, of type $\langle\langle e, \langle s, t\rangle\rangle, \langle e, \langle s, t\rangle\rangle\rangle$. It modifies a predicate like *believe* (of type $\langle e, \langle s, t\rangle\rangle$), [26] and provides the propositional-content-bearing-individual argument of that predicate via (presupposed) propositional anaphora. (It is adverbial in that *so* also carries other information on the Meijer in press account, such as the antecedent proposition's not being settled on the discourse Table.) This accounts for the movement properties of *so* (in contrast to *that*-clauses), and may also account for why *so* cannot be used as a response particle (see discussion in Meijer in press).

The behavior described above for *so* can also be seen with *as*. Consider (75′) and (77′):

(75′) A: My father gave his life so that we may have a chance to defeat this.
B: As you've told us.

(77′) a. I believe/claim/am afraid as much.
b. my belief/claim/fear that pigs fly
c. * my belief/claim/fear as much

Despite their many similarities, *so* and *as* do differ in their behavior, even in this propositional anaphoric use. One obvious difference is that, where *so* functions on its own, *as* in some cases also needs the word *much*, especially when in complement position; see (78).

(78) a. I believe so.
b. I believe as *(much).
c. I believe not.

Because of the way *so* can stand alone in this way, it has sometimes been considered to act as a response particle, with *not* as its negative counterpart (Sailor 2012; Needham

[26] Meijer in press: fn. 18 assumes that "an additional layer, e.g. Kratzers (1996) VoiceP, adds an attitude holder."

2012). Another difference between *so* and *as*, perhaps related to this last point, is that *so* can be combined with sentential adverbs (Meijer in press: fn. 2), where *as* and the other (non-null) propositional adverbs discussed here cannot; *not*, like *so*, is felicitous in such constructions.[27]

(79) Is John coming tonight?

a. Possibly so.

b. * Possibly as (much).

c. Possibly not.

d. * Possibly this.

e. * Possibly that.

f. * Possibly it.

g. * Possibly which.

h. Possibly.

The null complement is felicitous in this construction, as in (79h); we turn to this next.

2.4.5 Null complement anaphora

Though they don't contain an explicit anaphor of any sort, sentences with null complements can also be understood as anaphoric, referring to events, as in (80), or to propositions, as in (81).

(80) a. I asked Bill to leave, but he refused.

b. Sue was attempting to kiss a gorilla, and Harry didn't approve.

c. We needed somebody to carry the oats down to the bin, but nobody volunteered. (Hankamer & Sag 1976: (56))

[27]Some speakers find even (79a) to be marked, but the pattern in (79) is fairly robust. Explaining such speakers' objections to (79a) will remain a topic for future work.

(81) a. Paul cheated on the test, and his teacher knows.

b. Paul cheated on the test, and his teacher found out.

In both of the examples in (81), we interpret the null complement of *know/find out* as referring to the proposition introduced by the first clause: 'Paul cheated on the test'.

Null complement anaphora (NCA) can be interpreted as having an event or propositional referent, but never an individual referent, as noted in Shopen 1972, 1973; Grimshaw 1979; Saeboe 1996; Depiante 2000; Haynie 2009. Depiante 2000 gives the following illustration:

(82) a. The children know $[_{NP}$ the song $]$

b. The children know $[_{CP}$ that it is time to leave $]$ (Depiante 2000: 60: (7))

(83) a. The teacher told the children that it was time to leave even though they already knew _

b. * The children learned the song on Monday but by Friday they know longer knew _ (Depiante 2000: 60: (8))

Even though *know* can take either a nominal or clausal complement, as shown in (82), only the clausal—propositional—version is compatible with NCA, while the nominal—individual—version is not, as in (83).

Combined with a Kratzer-Moulton view of attitude verbs, this non-individual restriction might explain why NCA seems to be incompatible with many verbs which otherwise are thought to take propositional complements. For example, compare (81b) to (81c).

(81) b. Paul cheated on the test, and his teacher found out.

c. * Paul cheated on the dest, and his teacher discovered.

If a verb like *discover* can only take (propositional-content-bearing-)individuals as arguments, and NCA disallows individual-denoting antecedents, then we can explain the ungrammaticality of (81c). If *find out*, on the other hand, takes propositions—propositions, and not individuals bearing propositional content—as arguments, then the grammaticality of (81b) is not problematic. This might also be an answer to the puzzle posed by Williams 2012 regarding the behavior of predicates like *notice*—which like *find out* can take truly propositional arguments, and thus participate in NCA[28] —in contrast to predicates like *win* and *ready*, which take individual-type arguments—like *discover*—, and thus don't participate in NCA.[29] If correct, this raises a question about what else might distinguish *notice/find out* verbs from *discover/believe* verbs, which might explain, or at least confirm, this argument-type distinction. One possible answer might lie along the lines of the semantic characteristics discussed in White, Hacquard & Lidz in press: both types of verbs are representational and factive, but only the latter are assertive.

Hankamer & Sag 1976 discusses NCA in distinguishing two types of anaphora, surface anaphora and deep anaphora. On this account, surface anaphors are derived transformationally, and so have internal syntactic structure—and with it, certain syntactic requirements—, while deep anaphors show "no sign of having been syntactically complex at any stage" (i.e., have no internal syntax) (Hankamer & Sag 1976: 406). As a result, surface anaphors require a linguistic antecedent, while deep anaphors can be controlled pragmatically. Hankamer & Sag 1976 argues that NCA is an example of deep anaphora, as (following Bresnan 1971) is "sentential *it*", i.e., the propositional anaphor *it* discussed above. In contrast, Hankamer & Sag 1976 argues that *so* is a surface anaphor.

Because NCA involves an 'invisible' component, I want to be careful to distinguish it

[28]Williams 2012 (knowingly) "stretch[es] the term somewhat", using *NCA* more broadly than Hankamer & Sag 1976 use it, or than I am using it here. For Williams 2012, NCA includes implicit arguments of verbs, as in *Ron won*. I will not argue that such a "stretch" is problematic, nor the opposite. That said, the difference is worth being aware of. Future comparison of these perhaps-distinct classes, e.g., with the extraction facts noted in Depiante 2000, would be worthwhile.

[29]They don't fit under the Hankamer & Sag 1976 definition of NCA, that is; see previous footnote.

from other constructions which might appear similar. As Hankamer & Sag 1976 show, NCA is distinct from intransitive uses of verbs (where there is no object, null or otherwise, and thus no anaphora). The intransitive use of *eat* in (84), for example, tends be interpreted as having "general (unspecified))" object: i.e., it's not that he just won't eat soup and potatoes, but rather, he won't eat *anything*.[30]

(84) I bring him soup and potatoes, but he won't eat.

(Hankamer & Sag 1976: fn. 21: (i))

In contrast, the null complement of (85) is interpreted such that the speaker's wife doesn't approve specifically of the speaker's gambling, not that she doesn't approve of anything in general.

(85) I play cards and shoot dice, but my wife doesn't approve.

(Hankamer & Sag 1976: fn.21: (ii))

NCA is also distinct from the null objects—which, unlike NCA, can be individual-typed—in a language like Spanish (which allows for implicit objects much more widely than English), as in (86).

(86) A: Querés café?
Do you want coffee?
B: Sí, sí quiero _
Yes, yes I want (Depiante 2000: 61: (10))

Depiante 2000 demonstrates that Spanish null objects are subject to island restrictions in a way that NCA is not. Finally, NCA is distinct from Verb Phrase Ellipsis (VPE), which

[30]Though see Glass 2014 questioning how robust this assumption is.

Hankamer & Sag 1976 classifies as surface anaphora on the basis of arguments by Ross 1969 and Grinder & Postal 1971.

2.5 Parallels across domains

In arguing that the interpretation of tense should be considered an anaphoric process, Partee 1973, 1984 lays out some foundational properties of anaphora (exemplified in the individual domain, then paralleled in the temporal domain). These same properties are used by Stone 1997 to argue for the same parallels in the modal domain. In this section, I'll demonstrate that these same properties hold in the propositional domain.

2.5.1 Non-linguistic antecedents

The examples given thus far rely upon linguistic material (spoken or written; for manual linguistic material, i.e., anaphora in signed languages, see Sandler & Lillo-Martin 2006; Schlenker 2011) to serve as antecedents; that is to say, the anaphors refer back to entities introduced via language. But we can also use anaphors to refer back to content which has no linguistic antecedent, if there is some entity which is salient enough in the discourse to be available.

(87) [We're sitting in a high school classroom, when suddenly the door is pushed open, and in walks a goat.]
What is *that* doing here?!?

In (87), we understand the anaphor *that* to refer to the goat which has just walked into the room. The context does not presume that a goat had been mentioned earlier in discourse, and in fact does not even require that there have been any conversation taking place at the time of the goat's entry. There is no linguistic material which introduces or refers to a goat, either before or after the use of the anaphor, but the goat's salience in the context

makes it available for anaphoric reference. This is, in a sense, simply a more extreme version of the examples in (30) and (32).

Propositions can also be made salient enough in a context to be available for anaphoric reference, as noted in Hankamer & Sag 1976; Asher 1993: 229–230.

(88) Hankamer [observing Sag successfully ripping a phone book in half]:
I don't believe it. (Hankamer & Sag 1976: (32))

(89) [Mom walks into the living room, and sees her three children standing around the broken remains of a lamp.]
Mom: Who broke the lamp?
[Two of the children look at Dewey.]
Dewey: *That*'s not true!

In (89), the anaphor *that* refers to the proposition 'Dewey broke the lamp'. The mom's question is linguistic, but the question alone doesn't make this proposition salient enough to be referred to; contrast with (89′):

(89′) [Mom walks into the living room, and sees her three children standing around the broken remains of a lamp.]
Mom: Who broke the lamp?
Dewey: # *That*'s not true!

Following Hamblin 1973, we might take the question *Who broke the lamp?* to denote the set of propositions which answer it: {Huey broke the lamp, Louie broke the lamp, ...}. But, as we'll see in Chapter 3, *wh*-questions don't in fact make these propositions available for anaphoric reference. And, even if they were introduced by the question, none of them are more salient than one another, and so (89′) is bizarre. The other children's gaze towards Dewey, though, is enough to make 'Dewey broke the lamp' salient enough to

be felicitously referred to (and denied) anaphorically, in (89). This non-linguistic event makes a proposition available for anaphoric reference.

If (89) isn't convincing, due to the presence of the question,[31] we can also consider (90):

(90) [Jeremy is trying to impress his new roommate, Sam. Hearing Sam's footsteps approaching the door, Jeremy hurries off the couch and assumes a push-up position. As Sam enters the room, Jeremy is doing push-ups, 'counting': "Seventy-three, seventy-four..."]
Sam: I don't believe *that* for a second.

In (90), Sam doesn't believe that Jeremy has done the number of push-ups that he is (perhaps indirectly) indicating. The anaphor *that* refers to the proposition 'Jeremy has done 73 push-ups'. Unless we take the utterance of the number *seventy-three* alone to denote the proposition 'Jeremy has done 73 push-ups', then we must admit that non-linguistic material (i.e., doing push-ups in time with the utterance, such that the uttering might be perceived as counting) makes a proposition available for anaphoric reference.

Anaphors which refer to propositions, then, can pick up on non-linguistic antecedents, just like those which refer to individuals.

2.5.2 Definite anaphors with definite antecedents

In what Partee 1984: 245 calls the "paradigm case" for anaphora, an antecedent noun phrase refers to a specific individual and a subsequent pronoun refers to that same individual, as in (91):

(91) Sam is married. *He* has three children. (Partee 1984: (2a))[32]

[31] Though, again, see Chapter 3, §3.3.2 on the introduction of propositional discourse referents by *wh*-questions.

[32] Here, and beyond, formatting for anaphors and antecedents had been added.

Just as in (3), we have a singular individual introduced by a proper name, and that same individual referred to by a pronoun.

The propositional parallel is just as straightforward:

(92) Sam is married. He told me *that*.

In (92), the anaphor *that* refers to the singular proposition 'Sam is married', which is denoted unambiguously by the first sentence.

2.5.3 Indefinite antecedents

As nominal expressions in English can be classified as definite or indefinite, we can differentiate indefinite antecedents for individual anaphora from definite ones.

(93) Agnes brought a book to school. *It* is in her locker.

The indefinite *a book* is the antecedent for the anaphor *it*. Even though we might not know quite which book we're discussing, we can still make reference to it and comment on it.

Sentences can't be classified as definite or indefinite, so the parallel for propositional anaphora isn't entirely straightforward. The closest parallel is perhaps as in (94), where a proposition is referred to by an indefinite nominal.

(94) Victoria told me a rumor, but *it*'s not true.

In (94), the anaphor *it* refers to the rumor that Victoria told the speaker. Here I have omitted the underlining, because it's not clear whether the antecedent is really *a rumor*, or if the proposition is simply the one associated with, and named by—but not introduced by—the nominal.

2.5.4 Bound variables

As Partee 1973, 1984 notes, pronouns can behave as bound variables when under the scope of a quantifier. Partee 1984 gives an individual example, as in (95), as well as a temporal one, as in (96).

(95) Every woman believes that *she* is happy. (Partee 1984: (4a))

(96) Whenever Mary telephoned, Sam *was* asleep. (Partee 1984: (5a))

In (95), the anaphor *she* is bound by *every woman*, so we understand *she* to refer to each woman included in that set. There are multiple women, and each is happy. In (96), as Partee 1984 argues, the past tense of *was* is bound by *whenever*, so we understand it to refer to a number of different past times, each simultaneous with a time that Mary telephoned.

We can construct a similar example for propositional anaphora. For reasons that will become clearer in the next subsection, it's easier if we model our example off of (96):

(97) Whatever Rosie believes, Peter believes $\emptyset$.

In (97), the (null) anaphor refers to a proposition of the form 'Rosie believes p', which is denoted by the antecedent. But because it is under *whatever*, we understand there to be multiple such things, multiple beliefs p. And for each belief, the anaphor refers to that respective proposition: the anaphor is bound.

Propositional anaphors, then, can be bound, just like individual anaphors.

2.5.5 'Donkey-sentences'

Partee 1973, 1984 highlights as characteristic of anaphora cases where a pronoun acts as if bound, even though it is not c-commanded by its binder; that is, it behaves seman-

tically as if bound even though it is not in the right syntactic structural configuration to be bound. These are the famous "donkey-sentences" from Geach 1962; Kamp 1981, and many others.

(98) If Pedro owns a donkey, he beats *it*. (Partee 1984: (6a))

(99) Every farmer who owns a donkey beats *it*. (Partee 1984: (6b))

In both of these cases, the anaphor *it* refers to the donkey (or donkeys) owned. If Pedro, or any single farmer, owns multiple donkeys, we understand each of those donkeys to be beaten. In other words, the anaphor acts just as if bound.

The same can be shown for propositional anaphora:

(100) If anyone looks at the test before time starts, I will tell the principal $\left\{\begin{matrix} \textit{that} \\ \textit{so} \\ \textit{as much} \end{matrix}\right\}$.

(101) Every student who cheated on the test told her mother $\left\{\begin{matrix} \textit{that} \\ \textit{so} \\ \textit{as much} \end{matrix}\right\}$.

In (100), the speaker will tell the principal propositions of the form 'x looked at the test before time started' for anyone x who does so. If there are multiple such students, we understand the speaker to be committed to conveying multiple propositions to the principal. In (101), each student told her mother something like 'I cheated on the test': one proposition per student. In both cases, the anaphors behave as if bound.

Because of the syntax of the structures which make propositions available for anaphoric reference, most of the bound readings of propositional anaphors are donkey-like, the anaphor not being syntactically bound by its antecedent. Nevertheless, we have examples of both types of bound uses discussed by Partee 1984 within the propositional domain.

Partee 1984 Feature	Propositional equivalent
Non-linguistic antecedents	✓
Definite antecedents	✓
Indefinite antecedents	?/✓
Bound variables	✓
Donkey sentences	✓

Figure 1: Propositional equivalents of Partee 1984 features of anaphora

2.5.6 Other properties from Stone 1997

After showing that modals share the five properties from Partee 1984 listed above with tense, Stone 1997 notes three further parallels between modal anaphora and temporal anaphora. I briefly discuss these parallels, and why propositional anaphora doesn't display them.

Parallels in presuppositions about referents

Stone 1997 notes that for individual/tense/modal anaphora, the anaphor can carry certain presuppositions about its referent. This information can be used to disambiguate, but it can also lead to clashes:

(102) a. # Pedro owns a donkey. She beats it.

b. # When John saw Mary, she crosses the street.

c. # If the railroads merged, the line will face bankruptcy. (Stone 1997: (27))

The pronoun *she* presupposes that its referent is feminine, but there is no such antecedent in (102a), so the discourse is infelicitous. In (102b), the PRESENT morphology *-es* conveys a non-PAST time, but the only antecedent time available is PAST, indicated by *was.* And, using the Stone 1997 terminology, *will* conveys a VIVID modality, which is incompatible

with the conditional in (102c)'s REMOTE modality.

There doesn't seem to be a parallel in the propositional domain, however. Propositions don't have features associated with gender, number, tense, etc. Propositions can be true or false at a world, but there don't seem to be English anaphors which presuppose either of those features. This might be a characteristic of propositions, that they don't have the sorts of properties which can be encoded by an anaphor, or it might just be a fact about the English anaphors.

Parallels in adverbials and clauses

Following Hinrichs 1986, Stone 1997 notes that modal adverbs (*otherwise*) and modal conjunctions (*If*-antecedents), just like temporal adverbs and temporal conjunctions, introduce antecedents which license one another as well as other modal morphemes like *would* and *should*. Tellingly, this parallel is strictly between modality and tense; there is no equivalent parallel in the individual domain. For tense and modals, the particles which introduce times/situations are the same particles which pick up on them. With individual anaphora, these are distinct: names, indefinite nominals, and (some) quantifiers introduce individuals which can be referred to anaphorically by pronouns and definite descriptions. The same is true for propositional anaphora, in that the set of things that introduce propositions and the set of things that refer back to them are disjoint.

Parallels in modification

Following Hornstein 1993, Stone 1997 distinguishes between OPERATORS, which are functions from sentences to sentences, and so are iterable, from MODIFIERS, which impose constraints on specific entities, and so are not necessarily iterable. Hornstein 1993 shows that English tense is a MODIFIER, not an OPERATOR, and Stone 1997 shows the same for English modals.

Here, too, it's not at all clear what a propositional anaphoric parallel would look like (or even an individual anaphoric parallel). Tense and modality can be thought of as modifying a sentence which might otherwise omit information about the time or worlds in which is takes place. Individuals, however, don't modify sentences, but are described by them. Similarly, propositions don't modify sentences, but are named by them, and perhaps also are described by them (in the case of an embedded sentence).

2.5.7 Sloppy identity

According to Stone & Hardt 1999, it is a general feature of anaphora resolution that it can give rise to both strict and sloppy identity readings. Sloppy identity readings arise when an embedded anaphor in an elided (or otherwise reconstructed) phrase is interpreted differently from an anaphor in the antecedent phrase. The most common examples of sloppy identity make use of verb phrase ellipsis (VPE), as in (103).

(103) Susan loves her cat. Jane does too. (cf. Stone & Hardt 1999: (3b))

The verb phrase which is elided is *loves her cat*, and we understand *does too* to mean 'Jane loves her cat too'. Where we get a strict vs. sloppy identity ambiguity is who is picked out by *her* in this elided phrase. On a strict reading, the elided *her* refers to the same entity as the first *her*, namely Susan: Jane loves Susan's cat. On a sloppy reading, the elided *her* refers not to Susan, but to Jane, the pronoun's now-closest antecedent: Jane loves Jane's cat.

Stone & Hardt 1999 follows Hardt 1993, 1999 in characterizing sloppy identity as in (104):

(104) $C1 \ldots [_{XP} \ldots [_{YP}] \ldots] \ldots C2 \ldots [_{XP'}]$

(C1, C2: "controllers" of sloppy variable **YP**) (Stone & Hardt 1999: (2))

"We have an antecedent of category XP containing a sloppy variable YP. The interpretation of YP switches from controller C1 to C2" (302). Stone & Hardt 1999 presents (105) as "familiar examples of sloppy identity, with the antecedent in italics:"

(105) a. [NP [NP]]

Smith spent [[*his*] paycheck]. Jones saved it. (Stone & Hardt 1999: (3a))

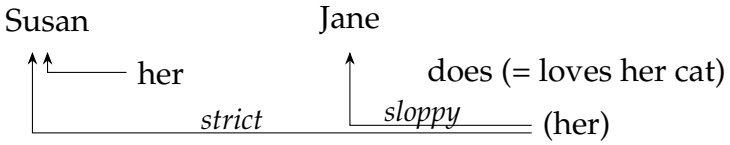
b. [VP [NP]]

Susan [loves [*her*] cat]. Jane does too. (Stone & Hardt 1999: (3b))

"In [(105a)], the NP *his paycheck* is the antecedent for the pronoun *it*. The embedded NP *his* is sloppy, switching from Smith to Jones. In [(105b)], the VP *loves her cat* is the antecedent for the VPE. The embedded NP *her* is sloppy, switching from Susan to Jane." (Stone & Hardt 1999: 302)

I find illustrations a bit easier than bracketed structures, so I represent the same contrast in a diagram. The example in (105b), for example, can be represented as in (106).

(106)



The anaphor *her* in the first sentence is interpreted as coreferential with *Susan* (indicated by an arrow), and the elided verb phrase, indicated by *does*, is interpreted as including another copy of that anaphor—this implicit content in parentheses. This second anaphor can be interpreted as coreferential with *Susan*—the strict identity reading—, or as coreferential with *Jane*—sloppy identity.

It is quite easy to construct examples of sloppy identity which involve proposition anaphora, as in (107).

(107) [Judy's son Jacob and Meredith's son Malcolm are in the same 5th grade class.]
Judy thought her son cheated on the test. Meredith believed *that*, too.

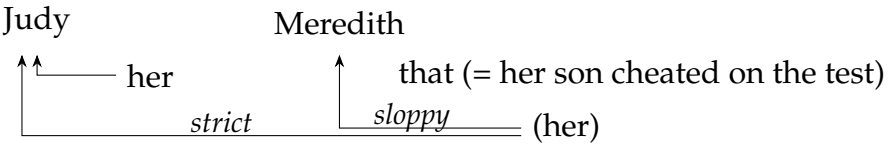
The second sentence of (107) allows for either a sloppy or strict reading: we can interpret the anaphor *that* as referring to either the proposition 'Judy's son cheated on the test' (the strict reading) or 'Meredith's son cheated on the test' (the sloppy reading). Some speakers report the strict reading of (107) being the unmarked reading, but a follow-up can sway a hearer's interpretation either further towards a strict reading, as in (107b), or towards a sloppy reading, as in (107a).

(107) a. Judy thought her son cheated on the test. Meredith believed *that*, too: she thought Jacob copied off of her Malcolm's work.

b. Judy thought her son cheated on the test. Meredith believed *that*, too: she didn't think Malcolm studied enough to get that A.

In this sort of example, though, the propositional anaphora is serving the same purpose as VPE, above: it is what allows for the 'repeated' instance of the sloppy variable (here, the pronoun *her*). This is sloppy identity involving a propositional anaphor, but not a sloppy interpretation *of* a propositional anaphor. We can make this clear if, just as above, we diagram the two readings available for the second sentence of this discourse; see (108).

(108)



We understand the propositional anaphor *that* as potentially referring to two different propositions only by virtue of the strict/sloppy readings of the pronoun *her*, which is 'repeated' through the anaphora resolution process.

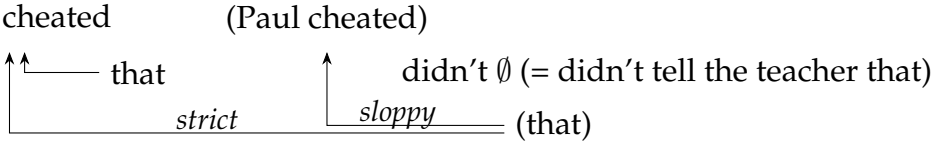
More interesting are examples where the sloppy variable is a propositional anaphor,

but these can be tricky to construct. Consider the example in (109):

(109) Ryu cheated on the test, but he didn't tell the teacher *that*. Paul didn't either.

The second sentence in this discourse is ambiguous, although speakers report a preference for the reading where Paul didn't tell the teacher that Ryu cheated. This is the strict identity reading, as the propositional anaphor *that* within the elided VP refers to the same proposition as the overt *that*: 'Ryu cheated on the test'. There is a second reading to this sentence, however, on which what Paul didn't tell the teacher is that he, Paul, cheated on the test. We can consider this a sloppy reading, as it's clear that the anaphor *that* refers to a different proposition: 'Paul cheated on the test'. What is particularly interesting about this reading of (109), though, is that this proposition isn't introduced by the mention of the name *Paul*, or by any explicit content; consider the diagram in (110).

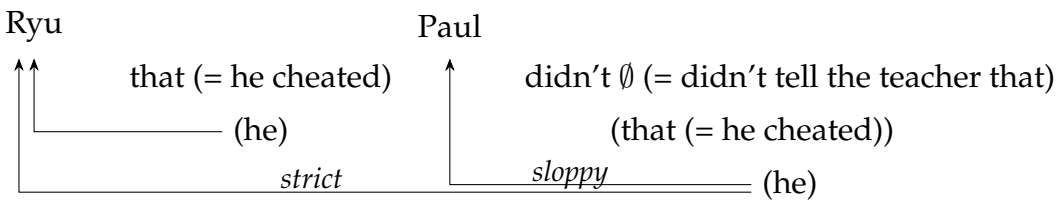
(110)



On this (attempted) representation, both the repeated anaphor *that and* its propositional antecedent in the second sentence are implicit.

Alternatively, this might not be a sloppy propositional variable, but a sloppy individual variable: the elided VP is [*tell the teacher that*], but that anaphor is in turn understood as '(that) he cheated (on it)', so we understand the elided structure to mean 'tell the teacher that *he* cheated (on it)'. And it's this 'he', under two layers of substitution, which seems to be behaving as the sloppy variable. It's only because this 'he' is interpreted as referring to Paul (as opposed to the strict reference to Ryu) that we reconstruct 'he cheated (on it)' as 'Paul cheated (on it)', to derive this sloppy reading. Compare the diagram in (110) to the one in (111).

(111)



Note, however, that the '(that) he cheated (on it)' meaning isn't represented explicitly in the first sentence of (109); it's only after we resolve the anaphor *that* in the first sentence—and only if we resolve it using a pronoun—that we understand the first sentence of (109), repeated in (112a), as (112b).

(112) a. Ryu cheated on the test, but he didn't tell the teacher *that*.

b. Ryu cheated on the test, but he didn't tell the teacher that *he* cheated (on *it*).

The example in (109), then, might better be considered an example of sloppy identity of an individual variable, even though it happens by means of a propositional anaphor.

It is difficult to construct an example where a propositional anaphor can be an ambiguously strict/sloppy variable, where the proposition to be picked up under the sloppy reading is introduced explicitly. Such a discourse would require a proposition-introducing clause to intercede between the first and (implicit) second occurrences of the propositional anaphor, making the first proposition (the strict antecedent) quite remote.[33]

To complicate matters further, some speakers have different behavior for the different propositional anaphors in cases like (109). Asher 1993 gives the examples in (113)

[33]For such an example to work, we would need four clauses, A–D, such that: A denoted a proposition; B included an explicit propositional anaphor, referring to A; C denoted a different proposition; and D included an implicit (elided or reconstructed) propositional anaphor. On a strict reading, the anaphor in D would refer to the proposition denoted by A, and on a sloppy reading, to that of C.

For D to be understood as including the same anaphor as in B, D would have to include a construction like VPE: *did too* or *didn't either*. And, to ensure that this VPE didn't pick up the verb phrase of C—instead picking out the proposition denoted by C, via the implicit anaphor—, there would have to be a valence/tense/aspectual mismatch between the verb phrase of C and the anaphor-containing D. And, on an SDRT account like Hunter & Asher 2016, both B and C would have to be discourse subordinate to A (in the sense of Asher & Vieu 2005). I've been unable to create such an example here, but one is theoretically possible.

as evidence that the "ambiguities of sloppy and struct readings appear to be a general trademark of abstract entity anaphora" (including propositional anaphora), but notes that "*this* and *that* and descriptions like *the same thing* support sloppy identity anaphora easily, while *it* has more difficulty in doing so."

(113) a. Mary has been going around saying that Al proposed to her, but Jo has been saying this (that) too. (Asher 1993: 228:(4.a))

b. Mary has been going around saying that Al proposed to her, but Jo has been claiming the same thing. (Asher 1993: 228:(4.b))

c. Mary has been going around saying that Al proposed to her, but Jo has been saying it too. (Asher 1993: 228:(4.f))

"Most speakers easily get the sloppy reading for [(113a)], in which what Jo has been saying is that Al proposed to Jo, with both *that* and *that* as anaphors. Many speakers do not get the sloppy reading of [(113c)]; the highly preferred reading is the (non-sloppy) reading on which Jo has been saying that Al proposed to Mary" (Asher 1993: 228). These examples, like (109), derive the strict/sloppy readings on the resolution of the pronoun *her*, not on the propositional anaphors themselves.

And we can extend this comparison to the other propositional anaphors discussed here, as in (114)–(121). In these examples, a strict reading of the second clause means that Mac said John would be late—which the (a) follow-ups attempt to bias. On a sloppy reading, Mac said that he (Mac) would (also) be late; the (b) follow-ups attempt to bias this reading.

(114) a. John said he would be late, and Mac said *this*, too. Apparently John has a conflict until 3, and he told Mac about it.

b. John said he would be late, and Mac said *this*, too. Apparently Mac has a conflict until 3. John didn't tell me his reason, though.

(115) a. John said he would be late, and Mac said *that*, too. Apparently John has a conflict until 3, and he told Mac about it.

b. John said he would be late, and Mac said *that*, too. Apparently Mac has a conflict until 3. John didn't tell me his reason, though.

(116) a. John said he would be late, and Mac said *it*, too. Apparently John has a conflict until 3, and he told Mac about it.

b. John said he would be late, and Mac said *it*, too. Apparently Mac has a conflict until 3. John didn't tell me his reason, though.

(117) a. John said he would be late, *which* Mac said, too. Apparently John has a conflict until 3, and he told Mac about it.

b. John said he would be late, *which* Mac said, too. Apparently Mac has a conflict until 3. John didn't tell me his reason, though.

(118) a. John said he would be late, *as* did Mac. Apparently John has a conflict until 3, and he told Mac about it.

b. John said he would be late, *as* did Mac. Apparently Mac has a conflict until 3. John didn't tell me his reason, though.

(119) a. John said he would be late, and *so* did Mac. Apparently John has a conflict until 3, and he told Mac about it.

b. John said he would be late, and *so* did Mac. Apparently Mac has a conflict until 3. John didn't tell me his reason, though.

(120) a. John said he would be late, and Mac did *so*, too. Apparently John has a conflict until 3, and he told Mac about it.

b. John said he would be late, and Mac did *so*, too. Apparently Mac has a conflict until 3. John didn't tell me his reason, though.

(121) a. John said he would be late, and Mac did, too. Apparently John has a conflict until 3, and he told Mac about it.

b. John said he would be late, and Mac did, too. Apparently Mac has a conflict until 3. John didn't tell me his reason, though.

Unfortunately, the data on these cases are not clear. Some speakers report that all of the (a) and (b) discourses are fine, indicating that all of these propositional anaphors (including the null complement in (121)) display a strict-sloppy ambiguity. Other speakers report that all of the (a) discourses are degraded and unacceptable, where the (b) discourses are fine, indicating a strong preference only for the sloppy reading. And some speakers fall in between, indicating that *this* and *that* freely allow for the strict/sloppy ambiguity, but strongly preferring the sloppy reading for the other propositional anaphors. What underlies this interspeaker variation regarding strict readings for propositional anaphors I leave as a question for future research.

Ultimately, the data provided here demonstrate that propositional anaphora is anaphora, showing many (if not all) of the same behaviors as anaphora in other domains. Propositional anaphors can be referential or bound, can have linguistic or non-linguistics antecedents, can appear in 'donkey' contexts, and appear to participate in strict/sloppy ambiguities.

2.6 Conclusion

Anaphoric reference to propositions is fairly widespread in natural language. In this chapter, I've laid the groundwork for a detailed investigation into this type of anaphora. In §2.2, I introduced the notion of anaphora broadly, giving examples of anaphora to individuals, events, and propositions, and located our discussion within the classes of anaphora discussed in Webber et al. 2003. I then introduced the notion of a proposition in §2.3 and explained its function in discussions of natural language semantics. In §2.4, I introduced the anaphors of English which can refer to a proposition, and discussed a few differences among these various anaphors. I leave it to future work—of the sort done by Needham (2012); Meijer (in press)—to determine the precise denotations of these anaphors such that these differences could be captured formally. This enumeration of the English propositional anaphors also begs for a comparison of such inventories crosslinguistically, to determine the range of variation that different language exhibit in this function; such an investigation is left to future work.

In §2.5, I used the features of individual anaphora identified by Partee 1973, 1984 and Stone 1997 to argue for the anaphoric nature of tense and modality (respectively), in order to argue that propositional anaphora, too, is anaphoric. I showed that propositional anaphora displays many of the same behaviors as other types of anaphora: allowing non-linguistic antecedents, bound variable readings, 'donkey' sentences, and strict/sloppy identity ambiguities. In this sense, propositional anaphora deserves that label: it is truly an anaphoric process, in parallel to individual, tense, and modal anaphora.

In the next chapter, we will examine the bounds of this parallelism between propositional anaphora and other kinds of anaphora, in particular individual anaphora. Chapter 3 investigates which structures introduce propositions into a discourse such that they are available for anaphoric reference, and in doing so surveys the empirical landscape

of when propositional anaphora is licensed. In the process of investigating that landscape and generalizing over the observed behavior, we will discover some similarities, and some differences, between propositional and individual anaphora.

CHAPTER 3

INTRODUCING PROPOSITIONAL DISCOURSE REFERENTS

3.1 Introduction

Karttunen 1969 is a systematic examination of which constructions license anaphoric reference to an individual, that is to say, which constructions introduce a *discourse referent* for an *individual*. Not all indefinite noun phrases, for example, make an individual available for anaphoric reference: consider (122) & (123).

(122) a. Bill has a car. (Karttunen 1969: (3a))

b. It is black. (Karttunen 1969: (3b))

(123) a. Bill doesn't have a car. (Karttunen 1969: (4a))

b. # It is black. (Karttunen 1969: (4b))

The words *a car* introduce a discourse referent which can be referred back to by the pronoun *it* in (122), but not in (123). Determining precisely when discourse referents are introduced for individuals was the goal of Karttunen 1969. This chapter addresses the same question in the propositional domain: Which constructions introduce a *propositional* discourse referent?

3.1.1 The goal

Karttunen 1969 introduces the notion of a *discourse referent*—something established by a certain construction which "justifies the occurrence of a coreferential pronoun or a definite noun phrase later in the text" (p. 5)—and then examines "under what circumstances discourse referents are established" (p. 5). The discourse referents Karttunen 1969 was interested in were individual ones, but here we will examine the question for propositional

discourse referents. The examination in Karttunen 1969 is comprehensive: Karttunen 1969 discusses indefinite noun phrases in the scope of modals, negation, and quantifiers, under factive, non-factive, and implicative verbs, in the antecedent of conditionals, and in imperatives and polar interrogatives. The current chapter aims to be at least this comprehensive, if not more so; the nature of this investigation will require examining a wide variety of constructions, including any phrase or clause which might be taken to convey a proposition, to see if that proposition is available for future anaphoric reference.

Karttunen's (1969) generalization was that "[a] non-specific indefinite NP in an affirmative sentence (single sentence or a complement) establishes a[n individual] discourse referent just in case the proposition represented by the sentence is asserted, implied or presupposed by the speaker to be true" (p. 13; underlining mine). By the end of this chapter, we will have a parallel generalization for which things establish propositional discourse referents, something of the form: 'A _____ establishes a propositional discourse referent just in case _____'. The generalization we seek here is parallel in terms of phrasing and aims, though the similarity of the generalizations will remain to be seen.

3.1.2 Background

There is currently one theory on the market for what introduces propositional discourse referents. Krifka 2013 argues that propositional discourse referents are introduced by the syntactic phrase projections for Tense (TP) and anything higher than it, including but not limited to Negation (NegP). For example, Krifka 2013 presents (124b) as a schematic for the sentence in (124a), where each $\hookrightarrow$ indicates a discourse referent being introduced.

(124) a. Ede didn't steal the cookie. (Krifka 2013: (4a))

$[_{\text{ActP}}$ ASSERT $[_{\text{NegP}}$ *Ede did-n't* $[_{\text{TP}}$ t_{Ede} t_{did} $[_{\text{vP}}$ t_{Ede} t_{steal} *steal the cookie*]]]

b. $\hookrightarrow d_{\text{speech act}}$ $\hookrightarrow d'_{\text{prop}}$ $\hookrightarrow d''_{\text{prop}}$ $\hookrightarrow d'''_{\text{event}}$

(Krifka 2013: (22))

The TP in (124b) introduces a discourse referent for the proposition 'Ede stole the cookie', and NegP introduces a discourse referent for 'Ede didn't steal the cookie'. (124b) also schematizes the introduction of discourse referents for events and speech acts; we won't focus on those here, except to contrast with the propositions we're interested in.

We will evaluate Krifka's (2013) proposal as we proceed with our investigation, examining how the data comports with this theory. I will argue that the Krifka 2013 proposal is on the right track, but is ultimately untenable, as we will see both (i) phrases of TP or higher which don't introduce propositional discourse referents, and (ii) phrases below TP which do introduce propositional discourse referents.

3.1.3 Methodology

In order to ensure that the observations made here are sound, I will be careful about which examples I use. Like in any good experiment, the more variables we can control for, the better. In this subsection, I'll discuss the choices that underlie the examples that we'll consider for the remainder of the chapter.

First, we'll identify an anaphor as being propositional by pairing it with a predicate which takes propositional arguments. The clearest such predicates are *true* and *false*, but other predicates which take sentential complements (e.g., *tell, doubt*) also fit the bill. Peterson 1982 lists the predicates in (17), repeated below, as those which take propositional arguments.

(125) Predicates of propositions

believes-, fears-, hopes-, wants-, thinks-, affirms-, denies-, -(un)likely, -(im)possible, -(in)consistent, -seems strange, -appears important, -sure, -true, -certain, -proposal, -hypothesis, etc. (Peterson 1982: (9))

I won't comment here on the validity of all of these, but the idea that certain predicates select for propositional arguments is sound. Some predicates that take propositional arguments also take individuals as arguments, as in (126), but some do not, as in (127). And, some that can take individuals do so with a different meaning, as in (128), often corresponding to different lexical items crosslinguistically.[34]

(126) a. I believe (that) Nancy is at the party.

b. I believe Joyce.

(127) a. I think (that) Nancy is at the party.

b. * I think Joyce.

(128) a. I know (that) Nancy is at the party.

b. I know Joyce.

The fact that many of these predicates also take individual-type arguments is not especially worrisome, as there is rarely ambiguity between propositions and individuals of the kind described thus far (e.g., persons). More relevant are nominalizations like *the fact that Nancy is at the party*, which are syntactically nominal (DPs), and thus of the same type as individuals. But it is not the case that we can interpret all sentences with *that*-clause complements as having covert nominalizations, as multiple substitution failures

[34]The *know* that takes a propositional argument, as in (128a), means something like 'to have a high credence in'. That same meaning applied to an individual argument like *Joyce* would mean something like 'to have a high credence in Joyce', which would then mean the same thing as *I believe Joyce*, as in (126b). But that isn't what (128b) means. Rather, the *know* which takes an individual argument, as in (128b), means something like 'be acquainted with', a meaning which does not extend to cover (128a). These two senses of English *know* are distinct verbs in, e.g., French, German, Greek, Hebrew, Mandarin, Spanish...

have been noted between propositions and their respective nominalizations (Prior 1971; Pietroski 2000; King 2002; Pryor 2007).

Many of the examples that will be presented as infelicitous can be made felicitous by picking a different predicate; indeed, in many cases, there are very natural follow-ups the speaker could felicitously utter that involve anaphors. Many of these 'fixed' variants, though, no longer make use of propositional anaphors, instead making anaphoric reference to an event. For this reason, we'll be especially careful to only use predicates which take propositions, but not events, as arguments. When demonstrative, felicitous event anaphora examples may be presented as a foil to infelicitous attempts at propositional anaphora.

Second, I'll be using single-speaker discourses. These can be construed as independent segments of a larger multi-participant discourse (as opposed to a speaker talking to herself), but importantly only a single speaker will be considered. Doing so will allow us to largely sidestep thorny issues of speakers possibly differing internal models of the discourse, their assumptions about which referents are available or salient in a discourse context. These sorts of misalignments might occur in discourses where there is later negotiation about these differences via explicit disagreement, but they can also occur entirely unbeknownst to the interlocutors; either way, focusing on a single speaker (who is not retracting a prior assertion or correcting themselves) allows us to avoid these problems entirely. Similarly, keeping to single-speaker discourses means we don't have to attempt to identify hearers' accommodation of new information: single speakers needn't accommodate themselves.

Because we'll be using single-speaker discourses, we won't be using response particles (like *yes* and *no*) as our anaphors, even though they have been analyzed as being anaphoric (Krifka 2013; Roelofsen & Farkas 2015). Instead, we'll use other propositional anaphors, and in particular the demonstrative *that*. The different anaphors have different

selectional restrictions, so some can be more or less marked in different contexts:

(129) a. ? Dustin proved the theorem. Lucas told me this.

b. Dustin proved the theorem. Lucas told me that.

c. # Dustin proved the theorem. Lucas told me it.

d. Dustin proved the theorem. Lucas told me as much.

e. Dustin proved the theorem. Lucas told me so.

f. ? Dustin proved the theorem. Lucas told me.

In general, we'll be using *that*, simply because it seems to be relatively unmarked. That said, if using another anaphor (like *it*) makes a sentence more natural, we can do so with confidence, without sacrificing the strength of our evidence. If any anaphor can felicitously refer back to a discourse referent (that we can be confident is propositional, given the predicates discussed above), then something must have introduced that discourse referent. That said, we'll stick with *that* as our preferred anaphor.

Whenever possible, we'll also try to keep the anaphor in complement position. This will help to avoid complications which might arise due to topicalization, which may have effects on anaphora resolution.

(130) Steve said (that) Nancy was at the party,

a. but Joyce doesn't know *that*.

b. but *that*'s something Joyce doesn't know.

Judgments may differ, but many speakers have the intuition that the more preferred antecedent of the propositional anaphor *that* differs in these two follow-ups. In (130a), the complement position anaphor preferentially refers to the proposition introduced by the matrix clause of the first conjunct, 'Steve said ...'. The clefted anaphor in (130b), how-

ever, preferentially refers to the proposition introduced by the embedded clause, 'Nancy was at the party'. Because the same first conjunct in (130) has follow-ups which can refer to either of these propositions, we should say that it introduces propositional discourse referents for both of them, in both cases; the distinction between (130a) and (130b) is not which discourse referents are available, but which is preferred (perhaps due to salience). Nevertheless, (130) demonstrates that topicalization, here via clefting (Fichtner 1993), has consequences for anaphora resolution. The exact nature of these consequences is beyond the scope of the current chapter, however. For now, we'll simply stick with anaphors in complement position, the one common exception being in composition with the predicate *true*.

Finally, clauses in a discourse can be related to one another by means of *discourse relations* (Hobbs 1985; Lascarides & Asher 1991, 1993). In particular, one can distinguish between discourse relations which are *coordinating* (such as Narration, Parallel, and Contrast) and those which are *subordinating* (such as Elaboration, Explanation, and Background) (Asher & Vieu 2005).[35] The structure described by these discourse relations has been argued to have consequences for the resolution of anaphora (Asher 1993; Asher & Vieu 2005), as only discourse referents in the "right frontier" (Polanyi 1988; see also Webber 1991) are accessible for anaphoric reference. As such, the examples here will be those which have a subordinating discourse relation between the clause hosting the anaphor and the antecedent, such that no content is 'removed' from the right frontier (i.e., such that the right frontier isn't advanced). For the same reason, we'll avoid discourses with intervening material between the potential antecedent clause and the anaphor-containing clause, lest some intervening material advance the right frontier and change the anaphoric availability of the earlier clause.

[35]It is worth noting that discourse structure is distinct from syntactic structure: a clause may be syntactically subordinate without implying that the content is conveys has a subordinate discourse relation (Blühdorn 2008).

(v) The penguins were yellow-brown, while the giraffes were black and white. (Blühdorn 2008: (3))

With those details squared away, we can turn to the various constructions and see which introduce propositional discourse referents. For each example, I'll provide a discourse containing both the construction under investigation and a follow-up containing an anaphor; the anaphor will be *italicized*. I'll then list out candidate antecedents for the anaphor, each of which will be accompanied by judgment marks of the type associated with these sorts of examples: ✓ indicates felicity; # indicates infelicity, and (one or more) question marks indicate (varying degrees of) uncertainty, usually with accompanying discussion in prose. I'll also provide right-aligned labels alongside each candidate antecedent, indicating the (part of the) construction associated with it.

3.2 Subclausal constructions

In this section, we'll examine constructions below the level of TP which might be taken to introduce a propositional discourse referent. In particular, we'll look at constructions which are associated with propositions, for instance, constructions that trigger the presupposition of a proposition, to see whether that proposition is then available for anaphoric reference.

3.2.1 Names

Proper names presuppose both the existence and the discourse salience of a referent. Proper names are Determiner Phrases (DPs), which are below TP.

(131) Nancy napped. Dustin told me *that*.

✓*that:* Nancy napped. MATRIX CLAUSE

#*that:* Nancy exists. NAME, EXISTENCE PRESUPPOSITION

#*that:* Addressee knows which Nancy is intended. NAME, SALIENCE PRESUPPOSITION

Neither the existence presupposition nor the salience presupposition are available antecedents for anaphoric reference. There are no other propositions which names are straightforwardly associated with, so we can conclude that names don't introduce propositional discourse referents.

3.2.2 Definites

Definite noun phrases, also DPs, presuppose the existence and salience of a referent.

(132) The cat napped. Dustin told me *that*.

✓*that:* The cat napped. MATRIX CLAUSE

#*that:* The cat exists. DP, EXISTENCE PRESUPPOSITION

#*that:* Addressee knows which cat is intended. DP, SALIENCE PRESUPPOSITION

Just like with names, neither the existence presupposition nor the salience presupposition are available antecedents. So, just as with names, definites do no introduce propositional discourse referents. This is perhaps not surprising, considering the ways in which names and definite descriptions behave similarly (Strawson 1950; Searle 1958).

3.2.3 Possessives

Possessive phrases (PossP) of the form x's y presuppose some relation that obtains between x and y. This relationship is prototypically one of possession (*Fran's property*), but can also range over a number of other relations, including inherent possession (*Fran's nephew*, *Fran's knee*), parthood (*the desk's bottom drawer*), location (*Fran's neighborhood*), and many others (Langacker 1995a; Alexiadou 2003). (These phrases also presuppose the existence of x and y, but those presuppositions are associated with the DPs within PossP.)

(133) Mike carried Dustin's backpack. Elle told me *that*.

✓*that:* Mike carried Dustin's backpack. MATRIX CLAUSE

#*that:* Dustin has a backpack. POSSESSIVE PHRASE

(134) Nancy hugged her brother. Lucas told me *that*.

✓*that:* Nancy hugged her brother. MATRIX CLAUSE

#*that:* Nancy has a brother. POSSESSIVE PHRASE

(135) Steve's rudeness angered me. I heard *that* on the radio.

??*that:* Steve's rudeness angered me. MATRIX CLAUSE

#*that:* Steve is rude. POSSESSIVE PHRASE

The anaphors in (133)–(135) cannot felicitously refer to the relation propositions presupposed by the various PossPs, regardless of the type of relation described by the PossP. In addition, the context of (135) makes the matrix clause unsuitable as an antecedent for the anaphor, because presumably a speaker is the highest authority on their own personal taste, which makes listing a radio report as a source for learning about one's own anger bizarre.

None of the possessive phrases given in (133)–(135) make their presupposed proposition available for anaphoric reference, so possessive phrases don't introduce propositional discourse referents.

3.2.4 Intersective Adjectives

Intersective adjectives introduce predications of their arguments. [36] For prenominal adjectives these predications are distinct from the matrix predication of a clause. For example, the adjective *red* in (136) is what conveys the information (in this context) that

[36]This is a semantic characterization, not a syntactic one. The intention here is to discuss adjectives in general, but without overgeneralizing to include predicates like *fake watch*, whose propositional content is less transparent than is necessary for our present investigation.

the entity picked out by *the ball* is red. This information is represented as a proposition 'the ball is red' distinct from the proposition denoted by the matrix clause 'the ball rolled down the stairs'.

(136) The red ball rolled down the stairs. Nancy told me *that*.

✓*that:* The red ball rolled down the stairs	MATRIX CLAUSE
#*that:* The ball is red.	ADJ PREDICATION

In (136), the ball's being red is entailed by the whole first sentence, but the report in the second sentence cannot felicitously describe Nancy as having only described the color. The proposition associated with the adjective is not available for anaphoric reference.

The first sentence in (137) has an intersective adjective not prenominally but as a modifier of the main predication of the clause, *is a[n] attorney*.

(137) Barb is a wealthy attorney. Mike told me *that*.

✓*that:* Barb is wealthy and an attorney.	MATRIX CLAUSE
#*that:* Barb is wealthy.	ADJ PREDICATION
#*that:* Barb is an attorney.	NP PREDICATION

The anaphor *that* cannot be taken to refer to either the adjectival predication or the main NP (*attorney*) predication. This attempt might be hampered by the context, which provides no motivation for wanting to refer to just one of these predications, as opposed to the total (*wealthy attorney*) predication. Even more specific contexts, however, don't allow anaphoric reference to just one of these predications:

(138) a. A: Who should we invite to our political fundraiser?
B: Barb is a wealthy attorney. # Mike told me *that*, even though he doesn't know she's an attorney.

b. A: Who can we find to represent our corporation in this case?

B: Barb is a wealthy attorney. # Mike told me *that*, even though he doesn't know she's wealthy.

The context of (138a) gives the speaker B a reason to want to talk about just Barb's wealth—any wealthy person makes a good donor, regardless of their occupation—but B's follow-up in (138a) which explicitly denies Mike's knowledge of Barb's job is self-contradictory. Similarly, the context of (138b) gives B a reason to want to talk about just Barb's job—any attorney can serve, regardless of their personal wealth—but B's follow-up which explicitly denies Mike's knowledge of Barb's wealth is incompatible with B's prior utterance. Neither of these predications are individually available for anaphoric reference; reference is only felicitous to their conjunctive whole.

Intersective adjectives, then, don't make propositions available for anaphoric reference, either prenominally or as a modifier of a main predication.

3.2.5 Verbs with lexical presuppositions

Some verbs carry presuppositional information in addition to their asserted main content. For instance, the verb *stop* presupposes that some state or process existed prior to the event time being described: in other words, *stop* presupposes that there was something to be stopped. This isn't a purely syntactic designation, but it does describe a group of English verbs which might behave differently, and so we'll examine them as a group.

(139) Steve stopped smoking. Nancy told me *that*.

✓*that:* Steve stopped smoking. MATRIX CLAUSE

#*that:* Steve used to smoke. VP, EXISTENCE PRESUPPOSITION

(140) Steve continued smoking. Nancy told me *that*.

✓*that:* Steve continued smoking. MATRIX CLAUSE

#*that:* Steve used to smoke. VP, EXISTENCE PRESUPPOSITION

The first sentence of (139) conveys the proposition 'Steve stopped smoking', but it also conveys the proposition 'Steve used to smoke' via presupposition. This presupposed proposition, however, is not available for anaphoric reference. Similarly for (140), which does not make the proposition 'Steve had been smoking' (cued by the presupposition trigger *continue*) available for anaphoric reference. These sorts of verbs with lexical presuppositions, then, don't introduce propositional discourse referents.

Up to this point, all of the constructions we have examined have supported Krifka's (2013) proposal. DP, PossP, AdjP, and VP are all below TP, and so according to Krifka 2013 should not introduce propositional discourse referents. And this is precisely what we have observed thus far.

3.2.6 Small clauses (PrP, Bowers 1993, Balasz 2012)

English small clause constructions are those in which a nominal and adjective appear (in that order) after a verb. These constructions have a number of different functions: they can introduce a predication, a cause, a result, or an epistemic state, among other things (Wilder 1991). There is some disagreement about the syntax of small clause constructions, including whether the nominal and adjective make up a constituent (Wilder 1991). Some authors calling them VPs, and others use a specific Predication Phrase (PrP) to model them (Bowers 1993; Balazs 2012). In all of these analyses, though, syntacticians agree that small clauses are below TP.

We can investigate the different types of small clauses individually. First, secondary predications, which Wilder 1991 compares to Kratzer's (1995) "stage-level predicates".

(141) Hopper ordered his steak rare. Joyce told me *that*.

✓*that:* Hopper ordered his steak rare. MATRIX CLAUSE

#*that:* The steak was rare. SMALL CLAUSE

(142) Steve left Nancy angry with herself. Barb couldn't believe *that*.

✓*that:* Steve left Nancy angry with herself. MATRIX CLAUSE

#*that:* Nancy was angry with herself. SMALL CLAUSE

In (141), the small clause [*his steak*] [*rare*] describes how Hopper ordered his steak (to be cooked). There is no associated proposition which is available for anaphoric reference, though; this makes some sense, as (141) doesn't entail that the steak was in fact cooked rare. (Hopper could have ordered it that way, only to be told that no steak was available at all.) In contrast, (142) does entail that Nancy was in fact angry with herself. Nevertheless, that proposition 'Nancy was angry with herself' fails to be available for anaphoric reference, at least from a subsequent clause. This proposition does seem to be available if the anaphor is in coordinate structure, a second predicate which is thus part of the same small clause, as in (143).

(143) Steve left Nancy angry with herself, and unhappy that *that* was true.

??*that:* Steve left Nancy angry with herself. MATRIX CLAUSE

✓*that:* Nancy was angry with herself. SMALL CLAUSE

The proposition 'Nancy was angry with herself' associated with the left predication of the coordinated small clause seems to be available for anaphoric reference, but only from within this shared coordinate structure. It is not available from beyond this structure, as in (142).[37]

[37]These coordinate examples are harder to construct with inanimate objects, though not impossible.

(vi) Hopper ordered his steak rare, and thrown out if *that* wasn't true.

To the extent that this example is grammatical and felicitous, this may be true in general of small clauses.

Small clause constructions also describe causative events, with a causative verb embedding the small clause. In (144), Steve caused Barb to be nervous, and in (145), Hopper caused Callaghan to be promoted.

(144) Steve made Barb nervous. She told Nancy *that*.

✓*that:* Steve made Barb nervous. MATRIX CLAUSE

#*that:* Barb was nervous. SMALL CLAUSE

(145) Chief Hopper had Officer Callaghan promoted, but Joyce doesn't believe *that*.

✓*that:* Chief Hopper had Officer Callaghan promoted. MATRIX CLAUSE

#*that:* Officer Callaghan was promoted. SMALL CLAUSE

Like (142), the predications described in (144) and (145) are entailed by the sentence: (144) entails that Barb was nervous, and (145) entails that Callaghan was promoted. Nevertheless, these propositions are not available for anaphoric reference from a subsequent clause. Just as we observed that a secondary predication small clause proposition is available for reference *within* that small clause (in (143)), the same is true for causative small clauses. The proposition 'Barb was nervous', associated with the small clause of (144), is available from within a coordinated predication that is part of the same small clause, as in (146), but not from a coordinated second small clause, as in (147).

(146) Steve made Barb nervous, and unhappy that *that* was true.

??*that:* Steve made Barb nervous. MATRIX CLAUSE

✓*that:* Barb was nervous. SMALL CLAUSE

(147) Steve made Barb nervous, and Nancy unhappy that *that* was true.

#*that:* Steve made Barb nervous. MATRIX CLAUSE

✓*that:* Barb was nervous. SMALL CLAUSE

Small clause constructions can also describe the result state of an event (Hoekstra 1988;

Wilder 1991).

(148) Joyce painted the room red. Jonathan told me *that*.

✓*that:* Joyce painted the room red. MATRIX CLAUSE

#*that:* The room is red. SMALL CLAUSE

(149) Lucas wiped the table clean, but I don't think *that*'s true.

#*that:* Lucas wiped the table clean. MATRIX CLAUSE

#*that:* The table is clean. SMALL CLAUSE

In (148), the room was red, as a result of Joyce's painting. This proposition, describing just the result state of the event, is not available for anaphoric reference in (148).

In order to try to get at this result state proposition, (149) is presented in the frame of a potential Moore's paradox (Moore 1942): ϕ *but I don't believe* ϕ, with an anaphor. If the anaphor is taken as referring to the asserted matrix proposition, then the discourse is "an absurd thing to say" (Moore 1942), because the speaker has just uttered something they don't believe as if they believe it.[38] If there is another available antecedent, however, this frame needn't lead to the same infelicity: there is nothing inherently absurd about ϕ *but I don't believe* ψ. As we can see in (149), though, there is no alternative proposition available for anaphoric reference. The anaphor in (149) cannot be taken as referring just to the proposition 'the table was clean'. The only available antecedent is the matrix clause, which renders (149) infelicitous.

Secondary predication, causative, and resultative small clause constructions don't make propositions available for anaphoric reference, at least external to the small clause itself. Epistemic small clause constructions (Wilder 1991), however, behave differently. Consider (150) and (151), which are presented in the same potential Moore's paradox

[38]This is a violation, not a flaunting, of Grice's (1975) Maxim of Quality.

frame as (149).

(150) Jonathan considers Nancy brave, but I don't think *that*'s true.

#*that:* Jonathan considers Nancy brave. MATRIX CLAUSE

✓*that:* Nancy is brave. SMALL CLAUSE

(151) Barb called Steve a liar, but I don't think *that*'s true.

#*that:* Barb called Steve a liar. MATRIX CLAUSE

✓*that:* Steve is a liar. SMALL CLAUSE

In (150), the small clause [*Nancy*] [*brave*] describes how Jonathan sees the world, and the proposition 'Nancy is brave' is available for anaphoric reference. In fact, the Moore's frame makes this proposition the only antecedent which makes (150) felicitous. Similarly, in (151), the anaphor *that* cannot refer to the proposition conveyed by the matrix clause, 'Barb called Steve a liar', without falling into Moore's paradox. It can, however, felicitously refer to the proposition associated with the small clause, 'Steve is a liar'. The propositions associated with epistemic small clauses, then, are available for anaphoric reference, even from subsequent clauses.

This observation, that the propositions associated with some small clauses are available for anaphora, presents a challenge to Krifka 2013. Small clauses, whether VPs or PrPs, are below TP, and so following Krifka 2013 should not introduce propositional discourse referents. To account for these data, one could argue that some (and only some) small clauses TPs, and then explain why tense is not present in these TPs. Alternatively, one could argue that these epistemic small clauses move for scope, thus putting them above TP (making them eligible to introduce a propositional discourse referent), while still remaining relativized to the doxastic worlds of the subject opinion-holder, not the speaker. I won't sketch these defenses of Krifka 2013 further here before examining the rest of the data we'd like to consider.

There is one other observation worth making about anaphora to small clauses, which also stands in contrast to the Krifka 2013 proposal. Krifka 2013 has a syntactic phrase introduce a discourse referent for itself: TP introduces a discourse referent for TP, NegP introduces a discourse referent for NegP. If this were extended to small clauses, we would expect a small clause—say, a PrP—to introduce a discourse referent for itself. The data we've seen so far, however, suggest that the difference between the small clauses that do and don't make propositions available for anaphoric reference is not the small clauses themselves, but rather the verbs that embed them. We can make this point clearer by looking at a minimal pair, two different embedding verb contexts, each embedding (at least string-identical) small clauses.

(152) [Francine and Rosa were wed in an airport casino, officiated by an Elvis impersonator.]
The clerk considered Francine and Rosa married, but I don't think *that*'s true.

(153) [Francine and Rosa were wed in a Baptist church.]
The pastor pronounced Francine and Rosa married, # but I don't think *that*'s true.

(152) and (153) have (at least what appears to be) the same small clause: [*Francine and Rosa*] [*married*]. In (152), this small clause is under an epistemic embedding verb, *consider*, and the anaphor *that* can felicitously refer to the proposition 'Francine and Rosa are married' despite the potential Moore's frame. In (153), the same small clause is under a resultative embedding verb, *pronounce*, as the event described is not one of having an opinion but of creating the state described. And in the context of this resultative embedding verb, the proposition 'Francine and Rosa are married' is not available for anaphoric reference. (And, due to the Moore's frame, this renders the second clause altogether infelicitous, as there are no non-absurd antecedents.) So, unless one wants to argue that the two small clauses in (152) and (153) are structurally different, then it is not the small clause itself doing the introduction (or non-introduction) of discourse referents, but the embedding

verb.

There is such a structural argument available: If one takes the small clauses under epistemic embedding verbs to be derived from infinitives, then not only are the small clauses in (152) and (153) distinct, but the former is a TP, and thus accords with the prediction from Krifka 2013. As was pointed out to me by John Whitman (p.c.), the small clause in (152) (but not the small clause in (153)) can take modal adverbs, as in (154).

(154) a. The clerk considered Francine and Rosa $\left\{\begin{matrix}\text{possibly}\\\text{probably}\end{matrix}\right\}$ married.

b. ?? The clerk pronounced Francine and Rosa $\left\{\begin{matrix}\text{possibly}\\\text{probably}\end{matrix}\right\}$ married.

Additionally, the small clause in (152) can be coordinated with an explicitly infinitival small clause, as in (155) (which is not the case for (153)).

(155) a. The clerk considered Francine and Rosa married and Joe and Bill to have been married.

b. ?? The clerk pronounced Francine and Rosa married and Joe and Bill to have been married.

Both (154b) and (155b) are strange given the meaning of *pronounce*: it's not much of a performative if it needs modal hedging, as in (154b); and the infinitive in (155b) would have to be understood as a retroactive pronouncement, which is unusual (if not legally attested). Nevertheless, the felicity of (154a) and (155a) give some credence to the notion that the small clauses in (152) and (153) are in fact structurally distinct. This would be a departure from current analyses of small clauses, however (Bowers 1993; Balazs 2012).

3.2.7 Adverbials

The final category below the level of TP we will consider are adverbials (AdvPs). First, we will look at adverbs which modify a DP (via an adjective).

(156) Joyce's recently single nephew went on a date, and she told Hopper *that*.

✓*that:* Joyce's nephew went on a date.	MATRIX CLAUSE
#*that:* Joyce's nephew is recently single.	ADVP
#*that:* Joyce's nephew is single.	MODIFIED BY ADVP

In (156), the adverb *recently* composes with the adjective *single*, to modify the DP *recently single nephew*. There are several propositions—potential propositional discourse referents, really—worth looking at in the first clause of (156). The proposition conveyed by the matrix clause is 'Joyce's nephew went on a date', the proposition conveyed by the adverb is 'Joyce's nephew is recently single', and the proposition conveyed by the structure the adverb modifies—that is, the DP minus the adverb—is 'Joyce's nephew is single'. We'll distinguish between these last two not because it matters for (156), but because it bears on the distinction made in the previous subsection between (i) a phrase introducing its own propositional discourse referent and (ii) a discourse referent being introduced by an embedder for its argument.

As just hinted at, this distinction doesn't matter for (156): the only proposition available for anaphoric reference is the one conveyed by the matrix clause. The adverb doesn't introduce a propositional discourse referent, either for its own phrase or for the phrase it modifies. This isn't true just of *recently*; in fact, a wide range of DP adverbs show the same behavior.

(157) Dustin moved a surprisingly heavy box, but Lucas didn't believe *that*.

✓*that:* Dustin moved a box. MATRIX CLAUSE

#*that:* The box was surprisingly heavy. ADVP

#*that:* The box was heavy. MODIFIED BY ADVP

(158) Just before the storm, Mike found a fortunately large umbrella, but I didn't believe *that*.

#*that:* Mike found an umbrella. MATRIX CLAUSE

#*that:* The umbrella was fortunately large. ADVP

#*that:* The umbrella was large. MODIFIED BY ADVP

(159) I just emailed a Craigslist poster about a hopefully available apartment, but Steve doesn't believe *that*.

✓*that:* I emailed a Craigslist poster. MATRIX CLAUSE

#*that:* The apartment is hopefully available. ADVP

#*that:* The apartment is available. MODIFIED BY ADVP

The proposition associated with each matrix clause in (157)–(159) is available for anaphoric reference, except for in the Moore's paradox frame in (158). Just like (156), none of the adverbs in (157)–(159) make a proposition available for anaphoric reference, either for the proposition they convey or for that of the phrase they modify. This includes adverbs which are intensional (*surprisingly* in (157), *fortunately* in (158)) and an adverb derived from an attitude verb (*hope*, in (159)).

Epistemic adverbs, however, are a systematic exception to this pattern.

(160) The magician presented a seemingly normal deck of cards, but I didn't believe *that*.

#*that:* The magician presented a deck of cards. MATRIX CLAUSE

#*that:* The deck of cards was seemingly normal. ADVP

✓*that:* The deck of cards was normal. MODIFIED BY ADVP

(161) Steve introduced Nancy to the candidate apparently most qualified for the job, but she didn't believe *that*.

✓/?*that:* Steve introduced Nancy to a candidate. MATRIX CLAUSE

#*that:* The candidate was apparently the most qualified for the job. ADVP

✓*that:* The candidate was the most qualified for the job. MODIFIED BY ADVP

(160) is presented in a Moore's frame which renders the matrix clause proposition an unsuitable antecedent for anaphora. Trying to understand the anaphor *that* as referring to the proposition associated with the adverbial—'The deck of cards was seemingly normal'—results in a similarly Moore's-like sense of self-contradiction. The sentence does have one very natural felicitous reading, though: the speaker didn't believe the deck of cards was real. This reading has the anaphor coreferential with the phrase being modified by the adverb, so the adverb must be introducing a discourse referent. The same is true in (161), where the phrase modified by the adverb has an associated propositional discourse referent available for anaphoric reference. (Here, understanding the matrix clause as antecedent requires accommodating a disagreement about memory, where Nancy didn't remember being introduced to a candidate.)

And, just to make the case that much stronger, we can construct minimal pairs to parallel (157) and (159) above.

(162) Dustin moved a seemingly heavy box, but Lucas didn't believe *that*.

✓*that:* Dustin moved a box.	MATRIX CLAUSE
#*that:* The box was surprisingly heavy.	ADVP
✓*that:* The box was heavy.	MODIFIED BY ADVP

(163) I just emailed a Craigslist poster about an allegedly available apartment, but Steve doesn't believe *that*.

✓*that:* I emailed a Craigslist poster.	MATRIX CLAUSE
#*that:* The apartment is allegedly available.	ADVP
✓*that:* The apartment is available.	MODIFIED BY ADVP

(162) differs from (157) only in which adverb is used, where only the epistemic *seemingly* makes a proposition available for anaphoric reference. The same is true for (159), which replaces (159)'s *hopefully* with the epistemic *allegedly*, with the consequence of now having an additional proposition as an available anaphoric antecedent. We can observe, then, that epistemic adverbs do introduce a propositional discourse referent for the phrases that they modify.

Like the small clause data, this represents a challenge to the Krifka 2013 proposal in two ways. Empirically, these epistemic adverbs are structures below TP which nevertheless introduce a propositional discourse referent. And, theoretically, they suggest that the discourse referent introduced is for the phrase modified by the introducer, not for the clause containing it.

This last point is of particular note, here, because the adverb cases highlight a point that the small clauses make unclear: the structure for which a discourse referent is introduced isn't obviously a syntactic constituent. For small clauses, there has been debate in the literature whether a small clause like *[Nancy] [brave]* is a constituent, but the bracketing for an adverbial structure like (162) is *[a [[seemingly heavy] box]]*. The words most

closely associated with the non-matrix proposition we can felicitously refer to in (162) are *heavy box*, but *[heavy box]* is not a constituent of the sentence. This might be assuaged by having the epistemic adverb move out of the DP such that it can scope over (and take as an argument) the phrase which had contained it, but I won't sketch out such an account here. Even so, these data still represent a sub-TP structure introducing a discourse referent, contra Krifka 2013.

We can also look at adverbs which modify VP. Like the adverbs which modify DPs, most such adverbs don't make a proposition available for anaphoric reference.

(164) Nancy ran quickly. Jonathan told me *that*.

✓*that:* Nancy ran quickly. MATRIX CLAUSE

#*that:* Nancy ran. MODIFIED BY ADVP

(165) Dustin sat still, but the teacher didn't believe *that*.

✓*that:* Dustin sat still. MATRIX CLAUSE

#*that:* Dustin sat. MODIFIED BY ADVP

(166) Steve immediately fled, but Nancy doesn't believe *that*.

✓*that:* Steve immediately fled. MATRIX CLAUSE

#*that:* Steve fled. MODIFIED BY ADVP

In (164), we can't understand Jonathan to have said only that Nancy ran (not mentioning the speed at which she ran): the anaphor *that* can't be taken to refer to the phrase that the adverb modifies. The anaphor can only be taken to refer to the proposition associated with the matrix clause—here, 'Nancy ran quickly'. The same is true for (165) and (166). In (165), it is perfectly consistent to believe that Dustin sat but didn't sit still, but we can't interpret (165) as felicitously describing such a situation; similarly, it is consistent to believe that Steve might have fled but not immediately, but (166) can't describe Nancy as having that belief.

On the whole, most VP adverbs don't make a proposition available for anaphoric reference. But, once again, the same class of exceptions exist here:

(167) Steve apparently fled, but Nancy doesn't believe *that*.

✓*that:* Steve apparently fled. MATRIX CLAUSE

✓*that:* Steve fled. MODIFIED BY ADVP

(168) Steve allegedly fled, but I don't believe *that*.

#*that:* Steve allegedly fled. MATRIX CLAUSE

✓*that:* Steve fled. MODIFIED BY ADVP

Here we have two variants of (166), but with epistemic adverbs. (167) is a minimal pair with (166), and (168) is a near-minimal variant, only in a Moore's frame to make the availability of the non-matrix proposition even clearer. In (167), the anaphor *that* can be taken to refer to either the matrix clause proposition ('Steve apparently fled') or to the proposition associated with adverb-modified VP ('Steve fled'). In (168), the Moore's frame precludes felicitous anaphoric reference to the matrix clause proposition; there is still a felicitous reading of (168), though, where the anaphor refers to the proposition donveyed by the *allegedly*-modified VP 'Steve fled'.

VP adverbs with epistemic modal flavor make the proposition associated with the phrase they modify available for anaphoric reference, just like DP adverbs. And, just as with DP adverbs, this constitutes an objection to the Krifka 2013 proposal, in that VP adverbs operate below TP. On the whole, we can conclude that where most adverbs do not introduce propositional discourse referents, epistemic adverbs do.

A summary of the observations made about subclausal constructions in this section is presented in Table 1.

Table 1: Subclausal constructions

	Construction		Introduce Propositional Discourse Referent?
Subclausal	Names		no (131)
	Definites		no (132)
	Possessives		no (133)
	Intersective adjectives		no (136)
	Verbs with lexical presuppositions		no (139)
	Small clauses	Secondary Predication	no (141)
		Causative	no (144)
		Resultative	no (148)
		Epistemic	yes (150)
	Adverbials	Modifying DP	some (160)
		Modifying VP	some (167)

3.3 Monoclausal constructions

In this section, we'll look at monoclausal constructions, including looking across sentence types, to see when propositional discourse referents are introduced. While some of these data might seem more 'basic' than the data covered in the previous section—and indeed, every example in the previous section had a matrix clause with an associated propositional discourse referent—, it seemed more fitting to progress up from the smallest structures to the largest. And while all of the examples thus far have been in declarative sentences, because the constructions being investigated were sub-TP, the results should be consistent across sentence types. In this section, however, we will pay more attention to the differences among sentence types.

3.3.1 Declaratives

Voice

As we have seen in the examples thus far, the proposition conveyed by an active voice matrix clause is available for anaphoric reference. To return to a basic example, consider (169):

(169) Barb went to a party. Nancy told me *that*.

✓*that:* Barb went to a party. MATRIX CLAUSE

The first sentence of (169) only has one clause, and it has an associated propositional discourse referent which is picked up by the anaphor *that* in the second sentence.

This is not specific to the active voice; passive matrix clauses also have an associated propositional discourse referent.

(170) A party was thrown last week. Steve told me *that*.

✓*that:* A party was thrown last week. MATRIX CLAUSE

The first sentence of (170) denotes a proposition which is available for felicitous anaphoric reference. This is perhaps unsurprising, and there is nothing about the Krifka 2013 proposal which might make us expect that passive clauses behave differently than active clauses in this respect, but it is nevertheless worth stating explicitly.

Negation

Under sentential negation, both the negative matrix clause proposition and the negated embedded clause proposition—the prejacent of negation—are available for anaphoric reference (recall Krifka 2013 and (124a)). To illustrate this, consider (171) and

(172):

(171) Barb didn't go to the party. Nancy told me *that*.

✓*that:* Barb didn't go to the party. MATRIX CLAUSE

(172) Barb didn't go to the party. Nancy told me *that*, but she's mistaken.

#*that:* Barb didn't go to the party. MATRIX CLAUSE

✓*that:* Barb went to the party. PREJACENT OF NEGATION

In (171), the anaphor *that* in the second sentence refers to the proposition denoted by the matrix clause of the first. In (172), the matrix proposition is not a suitable antecedent, because the follow-up clause denies the truth of whichever proposition is selected as antecedent, and denying the truth of the already-asserted first sentence would be self-contradictory. The other—and thereby only felicitous—reading of (172) is for the anaphor to refer to the prejacent proposition 'Barb went to the party'.

Sentential negation clearly involves the introduction of two propositional discourse referents. But what about constituent negation?

(173) a. It's not the case that Nancy has been able to go skiing, though people believe *that*.

b. Nancy has not been able to go skiing, though people believe *that*.

c. # Nancy has been not able to go skiing, though people believe *that*.

d. # Nancy has been able not to go skiing, though people believe *that*.

e. # Nancy has been able to not go skiing, though people believe *that*.

f. # Nancy has been able to go not skiing, though people believe *that*.

(173a–b) are sentential negation, so there is a proposition available for anaphoric reference that does not result in contradiction when contrasted with the *though* follow-up—namely,

the prejacent proposition, 'Nancy has been able to go skiing'. Examples (173c–f) are examples of constituent negation, and are infelicitous. To understand why, it is important to notice that the sentence connective *though* requires a contrast between two clauses (see Webber et al. 2003). A sentence without any negation can be infelicitous without this contrast: consider (174).

(174) # Dustin napped, though people believe *that*.

There is no proposition for *that* to pick up other than 'Dustin napped', which cannot then contrast with itself. In just the same way, (173c–f) have no alternative proposition available other than the proposition expressed by the first clause. These examples of constituent negation, then, don't make any additional propositions available for anaphoric reference beyond that of the matrix clause, which is available in the absence of constituent negation. Sentential negation introduces a propositional discourse referent, but constituent negation does not.

Modals

For sentences which contain modals, the proposition associated with the matrix clause is available for anaphoric reference, just as in (169–171). This is the case whether the modal has epistemic 'flavor', as in (175)–(176), or root flavor (Hoffman 1966, 1977), as in the deontic examples (177)–(178), and whether the modal is a possibility modal ((175) & (177)) or a necessity modal ((176) & (178)).

(175) Barb might have gone to the party. Nancy told me *that*, but she's not sure either.

✓*that:* Barb might have gone to the party. MATRIX CLAUSE

(176) Barb must have gone to the party. Nancy told me *that* after she looked at all the evidence.

✓*that:* Barb must have gone to the party. MATRIX CLAUSE

(177) Barb should have gone to the party. Nancy told me *that*, she thought it would cheer Barb up.

✓*that:* Barb should have gone to the party. MATRIX CLAUSE

(178) Barb must have gone to the pep rally. Nancy told her *that* after she read the cheerleader handbook.

✓*that:* Barb must have gone to the pep rally. MATRIX CLAUSE

More interesting is whether the prejacent of a modal is available for anaphoric reference in the same way that the prejacent of negation is. von Fintel & Gillies 2007 showed that the prejacent of an epistemic modal can be available for anaphoric reference, their context repeated in (179).

(179) [Pascal and Mordecai are playing Mastermind. After some rounds where Mordecai gives Pascal hints about the solution, Pascal says:]

There might be two reds. (von Fintel & Gillies 2007: (20))

[Mordecai, knowing the solution, responds:]

a. That's right. There might be.

b. That's right. There are.

c. That's wrong. There can't be.

d. That's wrong. There aren't. (von Fintel & Gillies 2007: (21))

The responses in (179a) & (179c) target the matrix proposition, 'There might be two reds', while the responses in (179b) & (179d) target the prejacent, 'There are two reds'. (179) shows that both propositions can be suitable antecedents; we can further demonstrate the availability of the prejacent by making the matrix clause proposition an unsuitable choice, as in (180) and (181).

(180) Barb might have gone to the party. Nancy told me *that*, but I don't quite trust her.

#*that:* Barb might have gone to the parry. MATRIX CLAUSE

✓*that:* Barb went to the party. PREJACENT OF MODAL

(181) [John's friend see him holding a red Solo cup at a party, and walks over to guess what he might be drinking. She says:]

You may have a beer, but I don't think *that*'s true. (I think you have red wine.)

#*that:* John might have a beer. MATRIX CLAUSE

✓*that:* John has a beer. PREJACENT OF MODAL

The follow-up in (180) provides a reason for the speaker to disbelieve whatever proposition the anaphor *that* refers to. Interpreting the anaphor to refer to the matrix clause proposition would be self-defeating, as the speaker would both endorse and disbelieve the proposition 'Barb might have gone to the party'. Instead understanding the anaphor to refer to the prejacent 'Barb went to the party' allows (180) to be internally consistent and felicitous. Similarly, the follow-up *I don't think that's true* in (181) makes the matrix clause proposition an unsuitable antecedent for *that*, as it would give rise to a Moore's paradox interpretation of the sentence. The sole felicitous reading of (181) is for the anaphor to refer to the prejacent of the modal, 'John has a beer'. Sentences with epistemic modals, parallel those with sentential negation, introduce a propositional discourse referent for the prejacent of the modal.

There are multiple ways to divide modals according to their modal 'flavor', each of which captures a different body of evidence a modal is sensitive to. Epistemic modals, for instance, as we have seen above, are evaluated with respect to what is known. Hacquard 2011 gives the following examples of different modal flavors:

(182) a. *Epistemic*

(In view of the available evidence,) John *must/might/may* be the murderer.

b. *Deontic*

(In view of his parents' orders,) John *may* watch TV, but he *must* go to bed at 8pm.

c. *Ability*

(In view of his physical abilities,) John *can* lift 200 lbs.

d. *Teleological*

(In view of his goal to get a PhD,) John *must* write a dissertation.

e. *Bouletic*

(In view of his desire to retire at age 50,) John *should* work hard now.

(Hacquard 2011: (1))

f. *Metaphysical*

(In view of the evidence that was available during the 3rd lap,) John *might* (still) have won the race. (cf. Hacquard 2011: (40b))

We can look at each of these flavors in turn.

Deontic modals are interpreted relative to a set of laws or rules. Because they are about obligations, they frequently target an addressee, as in (183):

(183) [John's doctor sees him holding a red Solo cup at a party. His doctor says to him:]
You may have a beer, but I don't think *that*'s true.

#that: John is allowed to have a beer. MATRIX CLAUSE

#that: John has a beer. PREJACENT OF MODAL

The sentence in (183) is string-identical to (the first two sentences of) (181); the only difference is whether *may* is interpreted epistemically (as in (181)) or deontically. Here, the doctor's presence biases a deontic reading, where John's doctor is perhaps reminding him of possible interactions between beer and John's medication. The Moore's frame precludes the interpretation of the anaphor *that* as referring to the matrix (modal) proposition, but, where (181) is felicitous due to the availability of an alternative antecedent proposition, (183) is infelicitous. We can't interpret (183) as meaning 'You are allowed to have a beer but I don't think you do have one', even though that is perfectly consistent. The proposition 'John has a beer' doesn't seem to be available for anaphoric reference in (183) the way it is in (181). There doesn't seem to be an alternative proposition available, which renders (183) infelicitous.

One might be wonder about the tense of the follow-up, given the future orientation of the permission being granted in (183). But modulating the tense doesn't change the felicity of the discourse.

(184) [John's doctor sees him holding a red Solo cup at a party. His doctor says to him:]

a. # You may have a beer, but I don't think *that* was true.

b. # You may have a beer, but I don't think *that* is true.

c. # You may have a beer, but I don't think *that* will be true.

Regardless of the tense of the follow-up, the prejacent of the deontic modal is unavailable for anaphoric reference. (In the modal examples that follow, I will abstract over the tense of the follow-ups, as modulating the tense doesn't change the resulting (in)felicity.)

We can also construct past oriented examples parallel to (180), which show the same behavior:

(185) The chaperone should have gone to the party, but Nancy told me *that*'s not true.

✓*that:* The chaperone was obligated to go to the party. MATRIX CLAUSE

#*that:* The chaperone went to the party. PREJACENT OF MODAL

(186) The chaperone should have gone to the party, but *that*'s not true.

#*that:* The chaperone was obligated to go to the party. MATRIX CLAUSE

#*that:* The chaperone went to the party. PREJACENT OF MODAL

The matrix clause proposition, the modal proposition, is available for anaphoric reference in (185), while that same reading is rendered self-contradictory in (186). The anaphors cannot be interpreted as referring to the proposition 'The chaperone went to the party' in either follow-up. There are natural follow-ups to the first sentence in (185)/(186) which make use of the anaphor *that* and which are perfectly felicitous, as in (187) & (188):

(187) The chaperone should have gone to the party, but *that* didn't happen.

✓*that:* (the chaperone's) going to the party EVENT ANAPHORA

(188) The chaperone should have gone to the party. *That* was her job.

✓*that:* (the chaperone's) going to the party EVENT ANAPHORA

These variants are examples of anaphoric reference to an event, though—the chaperone's going to the party—not to a proposition. The predicate *happen* can only apply to events, not to propositions. Examples (183)–(186) illustrate that sentences with deontic modals do not make the modal's prejacent available for propositional anaphora.

Ability modals are interpreted relative to an entity's abilities or capabilities. By virtue of this meaning, sentences with ability modals tend to be considered relative to (the present estimation of) some future eventuality, as in (189).

(189) Nancy can win the race next week, but I don't think *that*'s true.

#*that:* Nancy can win the race. MATRIX CLAUSE

#*that:* Nancy will win the race. PREJACENT OF MODAL

The Moore's frame in (189) precludes an interpretation of *that* as referring to the matrix clause proposition about Nancy's ability. And this renders (189) infelicitous, as there does not seem to be an available alternative proposition. The prejacent proposition about Nancy (actually) winning the race is not available for anaphoric reference. One might reasonably worry that the result in (189) is a reflex of its future orientation, so we should also consider a past oriented ability modal, as in (190). The past ability modal *could* is homophonous with the past metaphysical modal *could*, so we'll add some additional material which biases the ability reading, not the metaphysical reading.[39]

(190) Barb could have gone to the party last week. After all, she had the free time and a car. But Nancy doesn't think *that*'s true. (She thinks Barb was overseas.)

✓*that:* Nancy could have gone to the party. MATRIX CLAUSE

#*that:* Barb went to the party. PREJACENT OF MODAL

The anaphor in (190) can felicitously refer to the modal proposition denoted by the matrix clause. It can't refer to the prejacent proposition about Barb's attendance, it must refer to her (past) ability to attend.

Just like with the deontic modals, there are felicitous anaphor-containing follow-ups, but they are eventive rather than propositional.

(191) Nancy can win the race next week, but I don't think *that*'ll happen.

✓*that:* Nancy's winning the race EVENT ANAPHORA

[39]This intervening material is an explanation of the first clause, where explanation is a subordinating discourse relation. This intervening material, then, shouldn't advance the Right Frontier.

(192) Barb could have gone to the party last week. After all, she had the free time and a car. But Nancy doesn't think *that* was ever likely (to happen).

✓*that:* Nancy's going to the party EVENT ANAPHORA

The prejacent of an ability modal is not available for propositional anaphora.

Teleological modals are interpreted relative to a set of goals. These can be future oriented, as in (193), or about past goals, as in (194).

(193) There's an accident on the highway. Nancy should take the train, even if Mike doesn't believe *that*.

✓*that:* Nancy should take the train. MATRIX CLAUSE

✓*that:* There's an accident on the highway. PRIOR SENTENCE

#*that:* Nancy will take the train PREJACENT OF MODAL

(194) Oh, I see what went wrong with your cake. You had to add the flour before you add the eggs. But I doubt *that*.

#*that:* You had to add the flour before the eggs. MATRIX CLAUSE

#*that:* You added the flour before the eggs. PREJACENT OF MODAL

We can interpret (193) as meaning that Mike disbelieves that there's an accident—the anaphor referring to the proposition denoted by the first sentence—, or as disbelieving that Nancy should take the train—the anaphor referring to the proposition denoted by the matrix clause of the second clause. We seem to be unable to interpret (193) as meaning that Mike disbelieves that Nancy will in fact take the train, which would be the reading if the anaphor could felicitously refer to the prejacent of the modal. In (194), the matrix clause proposition is about the addressee's obligation (relative to their goals) to add the flour before the eggs, where the prejacent proposition is about that sequence actually obtaining. It is a perfectly consistent set of beliefs to think that the addressee was supposed

to have behaved in some way but did not in fact do so, but we can't interpret (194) as meaning that: the anaphor *that* can't be taken to felicitously refer to the prejacent proposition. As a result, (194) is infelicitous: the only available antecedent for *that* makes the sentence a Moore's paradox. The prejacent of a teleological modal, then, is not available for propositional anaphora.

Bouletic modals are interpreted relative to a set of desires, and can similarly be future oriented, as in (195), or past oriented, as in (196).

(195) Barb wants to have fun tonight. She should go to the party. But I don't think *that*'s true.

#that: Barb should go to the party — MATRIX CLAUSE

#that: Barb will go to the party. — PREJACENT OF MODAL

(196) Dustin should have taken me to the dance, even if Lucas doesn't believe *that*.

✓*that:* Dustin should have taken me to the dance. — MATRIX CLAUSE

#that: Dustin took me to the dance. — PREJACENT OF MODAL

The follow-up in (195) makes the matrix clause proposition an unsuitable antecedent for the anaphor *that*, as the speaker would publicly both endorse and reject the proposition 'Barb should go to the party'. The modal prejacent is not available for anaphoric reference in (195), even though it is consistent to believe that Barb should go to the party but will not in fact do so. (196) does not have the same self-contradictory frame, and so the matrix clause proposition is still a suitable antecedent for the anaphor. Just like in (195), though, the prejacent in (196) is not available for anaphoric reference. Sentences with bouletic modals, then, don't make their modal prejacents available for anaphora.

Metaphysical modals are the modals involved in counterfactuals, and they are interpreted relative to other ways the world could be or have been. In a branching time model of possible worlds (Prior 1967 and much subsequent work), this amounts to interpreta-

tion relative to the available evidence at some non-present time. For example, the modal in (197) is evaluated relative to the evidence available during the third inning of the game.

(197) In the third inning, the Phillies (still) might have won. Lucas didn't believe *that*, though.

✓*that:* The Phillies might have won. MATRIX CLAUSE

#*that:* The Phillies won. PREJACENT OF MODAL

Here, the anaphor *that* felicitously refers to the proposition denoted by the matrix clause of the first sentence: 'The Phillies might have won'. We can't take (197) to mean that Lucas doesn't believe the Phillies won, the modal prejacent. That said, the counterfactual in (197) implies that the Phillies did not, in fact, win—but this fact cannot explain the infelicity of anaphoric reference to the prejacent, as (198) illustrates.

(198) It didn't matter that Lucas struck out. The Cubs would have lost anyways. He doesn't believe *that*, though.

✓*that:* The Cubs would have lost. MATRIX CLAUSE

#*that:* The Cubs lost. PREJACENT OF MODAL

The counterfactual in (198) carries the opposite implication, that the prejacent is true in the actual world—here, that the Cubs in fact lost. Nevertheless, the prejacent is not available for propositional anaphora: we cannot understand (198) as meaning that Lucas doesn't believe that the Cubs lost. Regardless of its truth in the actual world, then, the prejacent of a metaphysical modal is not available for propositional anaphora.

We have observed that the prejacents of epistemic modals are available for propositional anaphora (von Fintel & Gillies 2007, (180)), but that the prejacents of other modals—at least deontic, ability, teleological, bouletic, and metaphysical modals—are not. The prejacents of non-epistemic modals may be available for other kinds of anaphora, including

event anaphora, but they do not have associated propositional discourse referents.

This distinction between epistemic modals on the one hand and all other modals on the other hand has been made previously in the literature. Following Hoffman 1966, 1977, Hacquard 2011 groups the non-epistemic modals together as 'root' modals, noting that there are empirical observations which fall along these lines. Epistemic modals tend to be speaker-oriented, where root modals are subject-oriented (Bybee, Perkins & Pagliuca 1994). There are also scopal differences, as epistemics can (and perhaps must) take scope over quantifier subjects (Brennan 1993; von Fintel & Iatridou 2003; Tancredi 2007; Huitink 2008), where root modals cannot: "epistemic modals tend to take widest scope whereas root modals take narrowest scope with respect to each other, and to various scope bearing elements" (Hacquard 2011: 1487). These classes also interact differently with tense, where root modals allow a forward or backshifting in time of evaluation, while epistemics do not (Hacquard 2011: 1513).

There have been different attempts to formally account for the differing behaviors of epistemic and root modals. I will focus on one in particular, that of Cinque 1999, not just because it is an influential account, but also because it is syntactic in nature, and thus bears on the Krifka 2013 proposal for the introduction of propositional discourse referents. Cinque 1999 argues for a strict hierarchy of functional projections, including modals; the relevant part of the hierarchy is provided in (199):

(199) $\text{Mod}_{\text{epistemic}} > \text{Tense} > \text{Aspect} > \text{Mod}_{\text{volition}} > \text{Mod}_{\text{deontic}} > \text{Mod}_{\text{ability}}$

Importantly, epistemic modals are functionally higher than both Tense and Aspect, where all other kinds of modals are lower. If we take the Krifka 2013 proposal to be "TP or higher", then the modal data presented here are compatible with Krifka 2013 under this Cinque 1999 syntax. Under Krifka 2013, epistemic modals, being higher than TP, would introduce their own propositional discourse referent for the matrix clause, while

TP would introduce a propositional discourse referent for the prejacent. Root modals, meanwhile, being below the level of TP, would introduce no propositional discourse referents, with the matrix clause referent introduced by TP.

Hacquard 2011 notes the connection between Cinque 1999 and propositions. Hacquard 2011 proposes a reconciliation of Kratzer 1981, 1991 (where all modals are given a uniform analysis) and Cinque 1999 by binding modals not to worlds but to events (including a matrix speech event), and restricting which modal base is possible (epistemic vs. root) by the structural location of the binding event:

> "I propose that, usually, only modals relative to speech and attitude events can combine with an epistemic modal base because only those events have associated 'propositional content' (i.e., the propositions that make up the attitude, such as a set of beliefs), which provides an information state required by an epistemic modal base. VP-event-relative modals, on the other hand, get a default circumstantial modal base". (Hacquard 2011: 1518)

Epistemic modals are those that are associated with propositional content—which might have its own associated propositional discourse referent—, while root modals have no such associated proposition—and thus there is no proposition to assign a discourse referent to. The prejacents of root modals, being event-relative, can be antecedents for event anaphora, but not propositional anaphora.

The syntactic proposal of Krifka 2013 thus accounts for the modal data we have seen in this section. It is less obvious, however, whether this story can be successfully extended to the subclausal data from the previous section. We have observed the systematic behavior of words with epistemic modal flavor, including sentential modals (as here), but also epistemic adverbs and epistemic small clause embedding verbs, all of which introduce propositional discourse referents. The Cinque 1999 hierarchy, however, doesn't itself explain the behavior of epistemic-flavor words outside of the normal phrasal hierarchy of functional projections, unless we insist on assuming a full Cinque 1999 hierarchy within

a single adverbial adjunct, for instance. That this epistemic/root distinction is robust and has been noted elsewhere allows us to feel more confident about the generalization we are heading towards, but the current approaches to formalizing that distinction don't yet obviously account for the anaphoric data explored here.

3.3.2 Interrogatives

We now turn to interrogative sentences. Where a declarative sentence is standardly taken to denote a proposition, an interrogative sentence is thought to denote a set of propositions (Hamblin 1973), the set of possible answers to the question.

Polar questions

Krifka 2013 proposes that the TP within a polar question introduces a proposition discourse referent:

(200) a. Did Ede steal the cookie?

b. $[_{\text{ActP}}$ *did*-QUEST $[_{\text{TP}}$ *Ede* t_{did}-PAST $[_{\text{vP}}$ t_{Ede} steal *the cookie*]]]
↪ $d_{\text{speech act}}$ ↪ d'_{prop} ↪ d''_{event}

(Krifka 2013: (21))

This propositional discourse referent is for the proposition which partitions the universe of possible worlds into possible answers. That is to say, for a question $\phi?$ which partitions the universe into ϕ-worlds and $\neg\phi$-worlds (and therefore has possible answers ϕ and $\neg\phi$), there is a discourse referent for ϕ. Under the Krifka 2013 proposal there is no discourse referent for $\neg\phi$, the complement proposition, even though it is also a possible answer and thus, under a Hamblin semantics for questions, one of the two propositions denoted by the question.

Krifka 2013 posits a second discourse referent for the complement proposition only in a polar question containing sentential negation, as in (201b):

(201) a. Did Ede not steal the cookie?

b. $[_{\text{ActP}}$ *did* QUEST $[_{\text{NegP}}$ *Ede not* $[_{\text{TP}}$ t_{Ede} *steal the cookie*]]]?
$\hookrightarrow d_{\text{prop}}$ $\hookrightarrow d'_{\text{prop}}$

(Krifka 2013: (53))

Here, according to Krifka 2013, the two propositional discourse referents are introduced by TP and NegP. Even though (200a) and (201a) have the same set of answers ({{*Ede stole the cookies*}, {*Ede didn't steal the cookies*}}), only the latter has discourse referents for both propositions.

We investigate this proposal for propositional anaphora in general, and not just response particles (as in Krifka 2013).

(202) Did Barb go to the party? Because Nancy told me *that* (and she's unreliable).

#*that:* Did Barb go to the party? / whether...	MATRIX CLAUSE
✓*that:* Barb went to the party.	PARTITIONING PROPOSITION
#*that:* Barb didn't go to the party.	COMPLEMENT PROPOSITION

(203) Did Barb go to the party? Steve refuses to believe *that*.

#*that:* Did Barb go to the party? / whether...	MATRIX CLAUSE
✓*that:* Barb went to the party.	PARTITIONING PROPOSITION
#*that:* Barb didn't go to the party.	COMPLEMENT PROPOSITION

In (202), the anaphor *that* can refer to the proposition which matches the polarity of the question. We cannot understand (202) as meaning that Nancy told the speaker Barb *didn't* go to the party, so the complement proposition is not an available antecedent for the anaphor. We see the same behavior in (203). These facts comport with Krifka's (2013) proposal: the complement proposition, though denoted by the question, is not available for anaphoric reference.

The question itself also is not available/suitable for anaphoric reference in (202)–(203).

This is perhaps not surprising in (203), as *believe* cannot take embedded interrogative complements, as in (204).

(204) * Nancy believes whether Barb went to the party.

The predicate in the second sentence in (202), *tell*, though, can take both *that*- and *whether*-complements.

(205) a. Nancy told me whether Barb went to the party.

b. Nancy told me that Barb went to the party.

(206) a. Nancy knows whether Barb went to the party.

b. Nancy knows that Barb went to the party.

The sentences in (205) differ in whether the complement of *tell* is an interrogative, as in (205a), or a declarative, as in (205b). They don't mean the same thing, either: (205b) entails (205a), but (205a) does not entail (205b). The same is true of *know* in (206); though *know*, unlike *tell*, allows anaphoric reference to the question, as in (207).

(207) Did Barb go to the party? Steve didn't know *that*.

✓*that:* Did Barb go to the party? / whether... MATRIX CLAUSE

#*that:* Barb went to the party. PARTITIONING PROPOSITION

(208) Did Barb go to the party? I asked Mike *that* (but he ignored me).

✓*that:* Did Barb go to the party? / whether... MATRIX CLAUSE

#*that:* Barb went to the party. PARTITIONING PROPOSITION

(207)–(208) are not examples of anaphoric reference to a proposition, but to a set of propositions. I won't discuss this sort of anaphora further here, nor why *tell* and *know* should allow for both *that*- and *whether*-complements but force argument anaphors to refer se-

lectively to different antecedents. For now, it is sufficient to note that polar interrogatives allow for non-propositional anaphoric reference to the question they denote, and for propositional anaphoric reference to the proposition that partitions that question (but not its complement).

_wh_- questions

Krifka 2013 doesn't take any stance on *wh-* questions, except in the context of Italian "polarity fragments" (Servidio 2012), where Krifka 2013: 8 suggests that, on an anaphoric theory of pronouns, "we can assume that the question introduces a propositional discourse referent for each felicitous answer." If the question *Who was at the party?* denotes the set of propositions which answer it—{{*Barb was at the party*}, {*Nancy was at the party*},...}—then we might have a discourse referent for each of those propositions. Because *wh-* questions also convey another proposition via presupposition—e.g., 'Someone was at the party'—, we will consider anaphoric reference to that proposition as well.

(209) Who was at the party? Because Nancy told me *that*.

#*that:* Someone was at the party.	EXISTENCE PRESUPPOSITION
?*that:* Who was at the party? / who...	MATRIX CLAUSE
?*that:* $\{x \mid x$ was at the party$\}$	TRUE ANSWER

The discourse in (209) can't be interpreted as meaning that Nancy told the speaker only that *someone* was at the party—the existence presupposition. There can be felicitous use of the anaphor *that*, but it's not entirely clear whether this anaphora to the question, or to the proposition which is the cell of the partition which is the true answer to the question. This latter use is perhaps odd, because the speaker presumably doesn't know which cell that is (if this is a true information-seeking use of a question), but (209) doesn't distinguish between the two.[40]

[40]For another example which is perhaps easier to get than (209), and which doesn't have an information-

We can use another predicate, *doubt*, which embeds propositions but crucially not interrogatives (Ginzburg 1993: 278, fn. 10), to pull these readings apart.

(210) Who was at the party? Because Steve doubts *that*.

#*that:* Someone was at the party.	EXISTENCE PRESUPPOSITION
#*that:* Who was at the party? / who...	MATRIX CLAUSE
#*that:* $\{x \mid x$ was at the party$\}$	TRUE ANSWER

There are no felicitous readings for (210), which is the same as (209) but with *doubt*. As intended, anaphoric reference to the question is ruled out by the predicate which does not select for interrogative complements. And the true answer, while indeed a proposition, is not available for anaphoric reference. (The existence presupposition continues to be unavailable.) This leaves no available propositional antecedents for the anaphor, so (210) is infelicitous.

And, just to show that indeed *doubt* makes for a suitable diagnostic for this difference between polar questions and *wh-* questions:

(211) Did Barb go to the party? Because Steve doubts *that*. POLAR

(212) # Who was at the party? Because Steve doubts *that*. WH

Polar questions make a proposition available for anaphoric reference, while *wh-* questions do not. This indicates that one of the other explanations for Italian polarity fragments suggested by Krifka 2013, such as those involving the background of the question (cf. Krifka 2001), is more appropriate than any proposal which assigns propositional discourse ref-

seeking use, consider the following:

(vii) [Elle and Mike have been caught robbing a bank, and are being interrogated in separate rooms by the police. After speaking to Elle, Chief Hopper enters Mike's room, and says "If you want a deal, you'll cooperate." He then asks:]
Who sold you your equipment? Because Elle already told me *that*.

erents to each answer to a *wh-* question.

Alternative questions

Krifka 2013 discusses alternative questions, asserting that alternative questions are "typically not based on a questioned proposition", such as (213), and hence don't have associated propositional discourse referents.

(213) A: Did Ede steal the cookie or the lollipop?
B: *Yes. / *No. / The lollipop. (Krifka 2013: (64))

Alternative questions with sentential alternatives like (214a) do introduce propositional discourse referents for each alternative, according to Krifka 2013, even though referring to them with response particles can be tricky.

(214) a. Is the door open, or is it closed?
b. [*Is the door open*], *or* [*is it closed*]*?*
↪ d_{open} ↪ d_{closed} (Krifka 2013: (65A))

We will examine each of these types of alternative questions in turn.

Alternative questions introduce a list of options (alternatives), where the speaker expects the answer to be among those options. Because English does not distinguish between them morphologically, alternative questions can be confused for polar questions, where the speaker is asking whether the correct answer is among (any of) the options listed. These forms can be distinguished phonologically, however, with different intonational contours. I'll indicate the difference using arrows: ↑ for a high/rising intonation, and ↓ for a low/falling intonation. This allows us to distinguish between an alternative

question, as in (215), and a polar question, as in (216).

(215) Would you like coffee$^{\uparrow}$, or tea$^{\downarrow}$? ALT

a. Tea, please.

b. # Yes, please.

(216) Would you like coffee$^{\uparrow}$, or tea$^{\uparrow}$? POLAR

a. Tea, please.

b. Yes, please.

Alternative questions, like *wh-* questions, also carry an additional sentence implication. Alternative questions presuppose that the speaker considers one of the alternatives to be correct (Biezma & Rawlins 2012), so we will examine the anaphoric potential of that proposition as well.

(217) Would you like coffee$^{\uparrow}$, or tea$^{\downarrow}$? Because Dustin told me *that*.

#*that:* Would you like coffee or tea? / which... MATRIX CLAUSE

#*that:* You would like coffee or tea. PRESUPPOSITION

#*that:* You would like coffee. LEFT DISJUNCT

#*that:* You would like tea. RIGHT DISJUNCT

There do not seem to be any felicitous readings of (217), which suggests that there are no suitable/available antecedents for the anaphor *that*. The presupposition is not available for anaphoric reference, nor is the question itself, nor either alternative. One might be concerned that this is simply a failure of context, for example that there is no reason to refer back to either of these alternatives, nor to expect one to be more salient than the

other; but consider (218):

(218) Would you like coffee$^{\uparrow}$, or tea$^{\downarrow}$? Because Dustin told me *that*, but I thought you hated $\left\{\begin{matrix}\text{coffee}\\\text{tea}\end{matrix}\right\}$.

#*that:* Would you like coffee or tea? / which...	MATRIX CLAUSE
#*that:* You would like coffee or tea.	PRESUPPOSITION
#*that:* You would like coffee.	LEFT DISJUNCT
#*that:* You would like tea.	RIGHT DISJUNCT

The follow-up in (218) tries to make the one alternative more salient, questioning it as contrary to prior expectations. No matter which of coffee or tea is chosen in last clause of (218), the anaphor *that* cannot felicitously refer to either alternative.

We can consider sentential alternative questions by simply expanding the disjuncts of (218). (From here on we will focus on anaphora to the alternatives, as reference to the presupposition or to the question is unlikely to be affected by this change.)

(219) Would you like coffee$^{\uparrow}$, or would you like tea$^{\downarrow}$? Because Dustin told me *that*, but I thought you hated $\left\{\begin{matrix}\text{coffee}\\\text{tea}\end{matrix}\right\}$.

#*that:* You would like coffee.	LEFT DISJUNCT
#*that:* You would like tea.	RIGHT DISJUNCT

The behavior here is the same as in (218): neither alternative is available for anaphoric reference.

Krifka 2001 notes an observation of an earlier version of Roelofsen & Farkas 2015, that *no* is a more acceptable response to an alternative question when "the second alternative is the sentential negation of the first", and explains why both response particles *yes* and *no* can be acceptable, giving (220b) as an example:

(220) a. Is the door open or not?

A: [*Is the door* [t_{door} *open*] *or* [~~*is the door*~~ [$_{NegP}$ *not* [t_{door} ~~*open*~~]*?*

b. ↪$d1_{open}$ ↪d2′[neg] ↪$d2_{open}$

B: $^{(?)}$*No. /* $^{(?)}$*Yes.*

(Krifka 2013: (66))

The notion from Krifka 2013 is that because both disjuncts have at their core the same clause, which is represented by two of the three propositional discourse referents floating around (d1 & d2), they are available for reference by response particles. I find *yes* to be a degraded response to (220a), and make the uncontroversial observation that *no* can serve functions beyond being a propositional anaphor. At the very least, we can note that this pattern does not apply to non-response particle anaphors, as (221) is not improved by replacing the second disjunct with *not*:

(221) Would you like coffee$^{\uparrow}$, or not$^{\downarrow}$? Because Dustin told me *that*, but I thought you hated coffee.

#that: You would like coffee. LEFT DISJUNCT

#that: You would not like coffee. RIGHT DISJUNCT

The version in (221) attempts to bias the anaphor towards referring to the proposition 'You would like coffee', which is conveyed both by the left conjunct and as the prejacent to what is assumed to be sentential negation in the right conjunct. But this proposition fails to be available for anaphoric reference, leaving (221) infelicitous.

Alternative questions don't make propositions available for anaphoric reference, whether the disjuncts are sentential or smaller. (This is not simply a reflex of anaphora to disjunctions in general, as we will see in section 3.5.) This runs counter to the proposal of Krifka 2013, unless there is some other reason that the discourse referents claimed to be introduced by sentential alternatives are unavailable for anaphoric reference. Absent such an explanation, it seems that propositional discourse referents are not introduced by

an alternative question, neither for the presupposition trigger by an alternative question, nor for the alternatives themselves.

3.3.3 Imperatives

There are multiple ways to construe an imperative as conveying a proposition: the proposition could describe the (new) obligation imposed on the addressee; the proposition could describe the worlds in which the addressee takes the desired action (thus fulfilling their obligation), or the worlds in which the desired action has been completed (possibily independently of the addressee). None of these propositions, though, are available for anaphoric reference:

(222) Shut the door! Nancy told me *that*.

#*that:* Addressee should shut the door.	IMPERATIVE∼MODAL
#*that:* Addressee will shut the door.	CULMINATION
#*that:* The door is shut.	RESULT STATE
?*that:* Speaker should instruct Addressee to shut the door.	SPEECH ACT

(223) Shut the door! Nancy (already) told you *that*.

#*that:* Addressee should shut the door.	IMPERATIVE∼MODAL
#*that:* Addressee will shut the door.	CULMINATION
#*that:* The door is shut.	RESULT STATE
#*that:* Addressee should instruct Addressee to shut the door.	SPEECH ACT

We cannot understand (222) as meaning that Nancy told the speaker that the addressee is obliged to shut the door, which is the meaning we would get if the anaphor *that* referred to the imperative itself. Similarly, the anaphor cannot be understood as referring to the proposition describing the culmination of the action described (the addressee's shutting the door), nor the result state of that action. The only reading of (222) which is edging

towards felicity (but is still highly marked) is the reading where Nancy told the speaker to instruct the addressee; this is an almost disquotational use of *tell*, where the anaphor *that* refers not to a proposition expressed by the imperative but to the speech act of directing. Lest we think this is something about the first-person nature of the follow-up in (222), we can see the same behavior in (223) except for the falling away of the speech act anaphora reading. Imperatives, then, don't make a proposition of any sort available for anaphoric reference.

Some researchers have claimed that imperatives describe propositions (in particular, desirable ones; see Wilson & Sperber 1988), or that imperatives can be interpreted as modal statements about the obligations they impose (when uttered in an appropriate context)—that is, *Shut the door!* can be understood as equivalent to *You should shut the door* (Schwager 2006, 2011). (Note that the attempted antecedent for the matrix imperative in (222) was glossed with a modal.) There are some reasons to resist this equivalence, for example, that imperatives crosslinguistically resist embedding and negation (Rupp 2002; Alcázar & Saltarelli 2014) in a way that modals do not.[41] Propositional anaphora is another reason to add to this list, as the matrix clause of a declarative sentence containing a modal does make a proposition available for anaphoric reference, as we saw in (175)–(178), where an imperative does not.

(224) a. # Shut the door, even though Lucas doesn't believe *that*.

b. You should shut the door, even though Lucas doesn't believe *that*.

(225) a. # Vaccinate your children, even if Jenny McCarthy doubts *that*.

b. You should vaccinate your children, even if Jenny McCarthy doubts *that*.

We can, of course, find examples of perfectly felicitous anaphoric reference to an imperative, as in (226). In these examples, though, the anaphor refers not to a proposition

[41] Though see Cormany 2013 for an argument for (limited) embedding of imperatives in English.

but to an event.

(226) Shut the door! Nancy already told you to do *that*.

✓*that:* shut the door EVENT

(227) Wash your hands! We won't start dinner until you do (*that*).

✓*that:* wash your hands EVENT

Krifka 2013 mentions imperatives only once, in noting that the response particles *yes* and *no* can be felicitous responses to imperatives in that they indicate compliance to a speaker's proposal to update the common ground. For Krifka, this is anaphoric to (a component of) the speech act, not a proposition. Krifka 2013 doesn't explicitly mention whether imperatives should introduce propositional discourse referents. Generalizing from how the proposal applies to declaratives and interrogatives—where TP introduces a proposition discourse referent, independent of the speech act operator (ASSERT or QUEST) it is under—it seems that the Krifka 2001 proposal would expect if imperatives contain a TP under a directive speech act operator, then that TP should behave no differently.

Krifka's (2013) proposal can be maintained if one adopts a syntactic theory under which imperative sentences do not contain Tense, along the lines of Zanuttini 1996, 2001. This sort of distinction has semantic counterparts, as well, as some consider imperatives to denote not propositions but properties (Hausser 1980; Portner 2004).

Imperatives, unlike declaratives and polar interrogatives, but like *wh-* and alternative interrogatives, do not introduce propositional discourse referents. The observations made in this section are summarized in Table 2.

Table 2: Monoclausal constructions

Construction			Introduce Propositional Discourse Referent?
Declarative			
Matrix	Active		yes (169)
	Passive		yes (170)
Prejacent of	Negation	Sentential	yes (172)
		Constituent	no (173)
	Modals	Epistemic	yes (181)
		Deontic	no (183)
		Ability	no (189)
		Teleological	no (194)
		Bouletic	no (195)
		Metaphysical	no (198)
Interrogative	Polar		yes (202)
	wh-		no (209)
	Alternative	Nominal	no (218)
		Sentential	no (219)
Imperative			no (222)

3.4 Multiclausal constructions

In this section, we'll look at constructions which involve multiple clauses in a single sentence, one embedded inside the other. As we have seen in the previous two sections, the proposition denoted by the matrix clause of a declarative is always available for anaphoric reference. As such, we'll be focusing here on whether the propositional content of embedded clauses (of different sorts) is similarly available.

3.4.1 Non-finite clauses

Much has been written about the behavior and underlying structure of English sentences that contain embedded non-finite clauses, especially comparing raising and control

constructions, as in (228) and (229) respectively.

(228) a. Joyce seems to understand. RAISING

b. Joyce$_i$ seems [t_i to understand].

(229) a. Joyce tries to understand. CONTROL

b. Joyce$_i$ tries [PRO$_i$ to understand].

Generally speaking, raising constructions are thought to involve an argument raised out from the embedded clause, while control constructions contain a covert pronoun, PRO, which allows the matrix subject (the controller) to be interpreted as part of the embedded clause but without movement (Napoli 1993; Carnie 2007). These constructions appear similar, but behave differently in certain ways, including famously with expletive subjects and idioms.[42]

(230) a. It seems to be raining. RAISING

b. * It tries to be raining. CONTROL

(231) a. The cat seems to be out of the bag. RAISING

b. * The cat tries to be out of the bag. CONTROL

Syntacticians continue to debate the underlying structure(s) of these constructions—e.g., whether PRO is base generated (Chomsky & Lasnik 1993) or whether control is derived via a different type of movement (Hornstein 1999, 2003)—as well as whether they are really all that different (e.g., arguments for unification along the lines of Bolinger 1961, 1967; Langacker 1995b; Polinsky & Potsdam 2006).

Sidestepping these debates, we will consider each of these differently-named constructions in turn, lest we conflate structures which are importantly different, as we inves-

[42]The sentence in (231b) is grammatical under a reading where an actual cat is trying to escape an actual bag, but (231b) cannot get the idiom reading we are interested in here, and so the sentence is marked with '*'.

tigate whether they make a (non-matrix) proposition available for anaphoric reference. And, while there are also disagreements about whether the embedded clause is a CP or a TP (Polinsky & Potsdam 2006; Carnie 2007), that debate makes no difference to the proposal made in Krifka 2013: whether or not a CP layer is present, there is a TP, and Krifka 2013 proposes that TPs introduce propositional discourse referents.[43] So according to the Krifka 2013 proposal, we should see felicitous anaphoric reference to the embedded clause content of all raising and control constructions.

Subject raising

Subject raising constructions contain an embedded clause whose missing (non-overt) subject is interpreted as being coreferential with the subject of the matrix clause; this subject is analyzed as having been raised out of the embedded clause, as in (228). Typical subject raising verbs include *seem*, *appear*, and *consider*. As per Krifka's (2013) prediction, these constructions make the proposition associated with the embedded clause available for anaphoric reference.

(232) Nancy seemed to be at the party. *That* was false, however.

#*that:* Nancy seemed to be at the party. MATRIX CLAUSE

✓*that:* Nancy was at the party. EMBEDDED CLAUSE

(233) Nancy seemed to be at the party. Her dancing shoes in the hallway led me to believe *that*.

?*that:* Nancy seems to be at the party. MATRIX CLAUSE

✓*that:* Nancy was at the party. EMBEDDED CLAUSE

(234) Nancy appeared to be at the party, but Barb refused to believe *that*.

✓*that:* Nancy appeared to be at the party. MATRIX CLAUSE

✓*that:* Nancy was at the party. EMBEDDED CLAUSE

[43]Even though these are non-finite clauses, they are thought to include tense information, supplied by the matrix clause (Stowell 1982).

(235) Nancy is considered to have been at the party, but *that*'s not true.

#*that:* Nancy is considered to have been at the party — MATRIX CLAUSE

✓*that:* Nancy was at the party. — EMBEDDED CLAUSE

All of the examples in (232)–(235) allow felicitous anaphoric reference to the proposition associated with the embedded clause, 'Nancy was at the party'. The matrix clause proposition is unsuitable as an antecedent in (232) because interpreting the sentence that way would make the speaker contradict herself; the same is true in (235). The matrix interpretation of (233) sounds particularly hedgey, with the speaker only willing to commit to being led to believe a *seem* claim, but remains available for some speakers. And the matrix interpretation of (234) is perfectly felicitous, along with the embedded clause interpretation. Importantly, though, in all of these subject raising examples we have felicitous anaphora to a proposition associated with the embedded clause, which suggests that these constructions introduce a propositional discourse referent for the embedded clause. This accords with the proposal made in Krifka 2013, as the embedded clause contains a TP and so should indeed introduce a propositional discourse referent.

Object raising

Object raising (or exceptional case marking (ECM), or "subject-to-object raising") constructions have the 'missing' subject of the embedded clause raised to the *object* position of the matrix clause.

(236) a. Steve wanted Nancy to be at the party.

b. Steve wanted Nancy$_i$ [t_i to be at the party].

Typical object raising verbs are *want* and *expect*. There is some debate about the status of these constructions, and whether they constitute true raising, but I will investigate them all the same, as discussed above.

Unlike the subject raising constructions seen above, object raising constructions do not behave as a single class: some object raising verbs allow for felicitous anaphoric reference to a proposition associated with the embedded clause, while others do not. The verb *expect* is an example of the former:

(237) Steve expected Nancy to be at the party, but Mike didn't believe *that*. (Mike thought she would stay home.)

??*that:* Steve expected Nancy to be at the party. MATRIX CLAUSE

✓*that:* Nancy would be at the party. EMBEDDED CLAUSE

The proposition conveyed by the matrix clause of the first conjunct in (237) presumably has an associated discourse referent, but is a strange choice to antecede the anaphor in the second conjunct: we have no reason to think Mike has access to Steve's expectations, let alone to disbelieve one of them. The much more natural antecedent for *that* is the proposition associated with the embedded clause, and indeed that is a felicitous reading of (237). This reading is reinforced by the final sentence, which supplies Mike's alternative view, one which contrasts not with the matrix clause but the embedded clause of the first conjunct. The proposition associated with the embedded clause of (237) is available for anaphoric reference.

We can see the same behavior with a present tense (and thus future-oriented) example, as in (238b).

(238) a. Steve expects Nancy to be at the party. His wearing his best tie leads me to believe *that*. MATRIX CLAUSE

b. Steve expects Nancy to be at the party. Her going dress shopping leads him to believe *that*. EMBEDDED CLAUSE

The clause embedded under *expect* has an associated propositional discourse referent.

We can see different behavior with clauses embedded under *want*, however, which are not available for propositional anaphora.

(239) Steve wanted Nancy to be at the party. He told me *that*.

✓*that:* Steve wanted Nancy to be at the party. MATRIX CLAUSE

#*that:* Nancy would be at the party. EMBEDDED CLAUSE

The anaphor *that* in (239) can only be felicitously interpreted as referring to the proposition conveyed by the matrix clause, about Steve's wants. (239) can't be taken to mean that Steve told the speaker anything about Nancy's actual party attendance. The same is true even if the follow-up biases an interpretation wherein Nancy did go to the party in the actual world, as in (240).

(240) Steve wanted Nancy to be at the party. The fact that he came home smelling like her perfume led me to believe *that*.

??*that:* Steve wanted Nancy to be at the party. MATRIX CLAUSE

#*that:* Nancy was at the party. EMBEDDED CLAUSE

The only available interpretation of (240) is strange, because it's not immediately clear why perfume would lead the speaker to learn something about Steve's desires. Nevertheless, the matrix interpretation is the only one available, if any interpretation is; we cannot interpret the anaphor (240) as referring to the embedded clause proposition. And where (240) is a parallel to (238a)—using *led me to believe*—, the *want* parallel to (238b) is simply impossible:

(241) Steve wanted Nancy to be at the party. Her being so kind to him led him to believe *that*.

#*that:* Steve wanted Nancy to be at the party. MATRIX CLAUSE

#*that:* Nancy would be at the party. EMBEDDED CLAUSE

In (241), the matrix interpretation is bizarre, as it would mean he was led to have beliefs about his own desire, and there are no alternative readings available, including the embedded clause reading.[44] Regardless of the follow-up, the proposition associated with a clause embedded under *want* cannot be the antecedent for a propositional anaphor.

We can have felicitous anaphoric reference to the embedded clause of *want*, but only with event anaphora, as in (242).

(242) Steve wanted Nancy to go to the party. *That* never happened, though.

✓*that:* Nancy's going to the party EVENT ANAPHORA

Object raising constructions do not behave uniformly with respect to their introduction of propositional discourse referents. Some object raising constructions, such as those which have *expect* as the embedding verb, do introduce a propositional discourse referent, in line with Krifka's (2013) proposal. Others, such at those which embed under *want*, do not have an propositional discourse referent available for anaphoric reference. This runs counter to the Krifka 2013 proposal, as the TP under *want* should introduce its own propositional discourse referent. This difference may be located in the nature of the verbs themselves: verbs like *want* may require an irrealis interpretation in a way that verbs like *expect* do not. These verbs differ in terms of their semantic classifications (White et al. in press), and they behave differently in languages with more robust subjunctive mood systems like Spanish, where the complement of *querer* 'want' gets the subjunctive but the

[44]The follow-up in (241) uses *believe* to ensure that the anaphor is propositional. The more natural follow-up *... led him to want that* is felicitous, but then we're no longer dealing with a propositional anaphor, as *want* doesn't take propositional arguments. We can see this, as *want* doesn't take CP complements. Even in the Englishes where *want* can embed *that*-clauses (e.g., in Jewish English, denoted by '✡' in (4), they are not truly CPs:

(viii) 1. Mike wants the Mets to win.
2. * Mike wants that the Mets will win.
3. * Mike wants that the Mets win.
4. ✡ Mike wants that the Mets should win. (= Mike wants the Mets to win.)

complement of *suponer* 'suppose, expect' does not.[45] These differences in propositional discourse referent introduction might be attributable to the verbs themselves, but cannot be captured at the level of the "object raising verb" classification.

Subject control

Subject control constructions contain an embedded clause whose missing (non-overt) subject is interpreted as being coreferential with the subject of the matrix clause, but unlike in raising constructions, this coreference occurs via control of a covert pronoun (PRO, which does not need to move for case assignment).

(243) a. Nancy tried to be at the party.

b. Nancy$_i$ tried [PRO$_i$ to be at the party].

The matrix verb of a control construction has a theta role for its external argument, unlike in a raising construction, which is why control constructions don't allow for expletive subjects, and why idioms lose their idiomaticity under control predicates. These are verbs like *claim* and *try*. Regardless of the nature of the embedding verb (and its theta assigning properties), control constructions are analyzed as involved (at least) an embedded TP, so Krifka 2013 predicts that there should be a proposition associated with the embedded clause which is available for anaphoric reference.

Like object raising constructions, however, subject control constructions do not behave as a uniform class. Control verbs like *claim* do allow for anaphoric reference to their embedded clause propositions.

(244) Nancy claimed to be at the party, but *that* wasn't true. (She was at the library.)

#*that:* Nancy claimed to be at the party. MATRIX CLAUSE

✓*that:* Nancy was at the party. EMBEDDED CLAUSE

[45]The Spanish verb *esperar* also carries the (irrealis) sense of 'hope', so is not the most appropriate comparison for this purpose. The complement of *esperar* gets the subjunctive, unlike that of *suponer*.

(245) Nancy claims to be at the party, but *that* isn't true. (She is at the library.)

#*that:* Nancy claims to be at the party. MATRIX CLAUSE

✓*that:* Nancy is at the party. EMBEDDED CLAUSE

The matrix clause proposition of (244) is an unsuitable antecedent for the anaphor in the second clause, because immediately denying one's own assertion makes a speaker self-contradictory. There is a perfectly natural interpretation of (244), however, where *that* refers to the proposition associated with the embedded clause, 'Nancy was at the party'. The same behavior pattern can be observed in the present tense version in (245).[46]

The subject control verb *try*, however, does not allow for anaphoric reference to its embedded clause proposition:

(246) Nancy tried to be at the party, but *that* wasn't true. (She was at the library.)

#*that:* Nancy claimed to be at the party. MATRIX CLAUSE

#*that:* Nancy was at the party. EMBEDDED CLAUSE

The matrix clause interpretation of (246) is ruled out by the self-contradictory nature of the second conjunct. And, even with the final clause follow-up which biases an interpretation in favor of resolving the anaphor as referring to the embedded clause proposition, no such interpretation is available. There is no available propositional discourse referent for the embedded clause of (246).

[46]Hankamer & Sag 1976 presents the following example, noting that *it* refers to the proposition 'Betty is pregnant':

(ix) That Betty is claimed to be pregnant doesn't make it true. (Hankamer & Sag 1976: (101))

I exclude it from the main text as it doesn't fit the methodology I have adopted for this chapter.

We can see the same in the present tense:

(247) a. Dustin tries to be helpful, but Elle doubts *that*. She thinks he gets in the way on purpose.

b. # Dustin tries to be helpful, but Elle doubts *that*. She thinks he ends up getting in the way.

The follow-up in (247a) makes it clear that what Elle doubts is the proposition associated with the matrix clause, about Dustin's trying. And (247a) is felicitous. The follow-up in (247b), though, indicates that what Elle doubts is that Dustin is indeed helpful, regardless of his intentions—in other words, the proposition associated with the embedded clause. This version is infelicitous, however, which indicates that there is no propositional discourse referent available for that embedded clause content.

The subject control verb *try*, then, does not allow for anaphoric reference to its embedded clause content, where the subject control verb *claim* does. As with object raising verbs, this presents a challenge to the Krifka 2013 proposal, as both *try* and *claim* take complements which contain (at least) TP. Subject control constructions do not pattern as a uniform class with respect to their introduction of propositional discourse referents, which would require a finder distinction (e.g., among different kinds of TPs) than Krifka 2013 provides.

Object control

Object control constructions have the subject of the embedded clause—analyzed as a covert PRO—interpreted as coreferential with—controlled by—the object of the matrix

clause.

(248) a. Nancy persuaded Jonathan to leave.

b. Nancy$_i$ persuaded Jonathan$_j$ [PRO$_{*i/j}$ to leave].

Object control verbs include *ask*, *convince*, *force*, and *persuade*. As with the other non-finite clause complement examples we've seen, Krifka 2013 predicts that these constructions should all allow for felicitous propositional anaphora, as the embedded TPs introduce propositional discourse referents.

In fact this is not the case, as object control constructions do not allow for anaphoric reference to a proposition associated with the embedded clause.

(249) Nancy asked Barb to be at the party, but Jonathan didn't believe *that*.

✓*that:*Nancy asked Barb to be at the party. MATRIX CLAUSE

#*that:* Barb was at the party. EMBEDDED CLAUSE

(250) a. Nancy asked Barb to be at the party, but Jonathan didn't believe *that*. He thought Barb came uninvited.

b. # Nancy asked Barb to be at the party, but Jonathan didn't believe *that*. He thought Barb stayed home.

The anaphor in (249) can only be taken to refer to the proposition conveyed by the matrix clause—about Nancy's asking—and not to the proposition associated with the embedded clause—about Barb's attendance. We can make this contrast starker by supplying follow-ups which explain Jonathan's disbelief (of each intended antecedent proposition), as in (250). In (250a), the follow-up contrasts with the matrix clause proposition, explaining why Barb attended (coming uninvited, as opposed to being asked), and this discourse is felicitous. In (250b), however, the follow-up contrasts with the proposition associated

with the embedded clause, giving an alternative to Barb's attending the party. The discourse in (250b) is infelicitous, which indicates that *that* cannot refer to the embedded clause content.

The same behavior is true for other object control verbs, though they are harder to demonstrate in the same way. The verbs *convince*, *force*, and *persuade* are factive, so they entail the truth of their complements.[47] Asserting the falsity of their complements, then, entails their falsity as well: if Nancy didn't go to the party, then Steve didn't force force her to go (though he might have tried). Instead of denying, then, we can demonstrate by explaining:

(251) a. Steve persuaded Nancy to be at the party. I know *that* because I overheard them. MATRIX CLAUSE

b. # Steve persuaded Nancy to be at the party. I know *that* because I saw her there. EMBEDDED CLAUSE

(252) a. Barb convinced Nancy to leave the party. I know *that* because I overheard them. MATRIX CLAUSE

b. # Barb convinced Nancy to leave the party. I know *that* because I saw her driving away. EMBEDDED CLAUSE

The follow-up in (251a) explains that the speaker knows what they know by hearing Steve and Nancy talk, which is one way that persuasion can occur. The follow-up in (251b), on the other hand, explains that the speaker's evidence is seeing Nancy at the party; this is enough evidence for asserting that Nancy was at the party, but isn't quite strong enough evidence for asserting that (she was there *because*) Steve persuaded her. (Compare (251b) to a variant with *must have persuaded*, where suddenly this is good enough evidence

[47] Lawler 2004 calls these *if*-predicates, in that they entail the truth of their complements but their negation entails nothing about the truth or falsity of the same. This contrasts with, e.g., implicative predicates like *manage*, which are factive and whose negation entails the falsity of their complements.

for the matrix conjecture.) That (251b) is infelicitous, despite the speaker having good evidence that Nancy was at the party, demonstrates that *that* cannot be taken to refer to the proposition associated with the embedded clause. There is a propositional discourse referent available for the matrix clause content, but not for the embedded clause content. The *convince* pair in (252) is exactly parallel.

Object control constructions, then, do behave as a uniform class in contrast to object raising and subject control constructions. But, just like both object raising and subject control constructions, object control constructions serve as a counterargument to the proposal in Krifka 2013. These are constructions which contain embedded TPs (if not also CPs), but which nevertheless fail to make a propositional discourse referent available for subsequent anaphoric reference.

3.4.2 *Likely* constructions

Likely constructions are those that use the predicate *likely* (and its peers, including *unlikely*, *fortunate*, etc.). These are sometimes considered raising constructions (e.g., Carnie 2007), as they can appear with expletive subjects and can take non-finite complements, as in (253). But, these are adjectives, not verbs, and they can also appear with finite complements, as in (254), so we will consider them separately (erring on the side of redundancy over conflation).

(253) a. It is likely to rain.

b. Dustin is likely to win.

(254) It is likely that Dustin will win.

These complements are TPs, and so Krifka 2013 predicts that propositional anaphora should be licensed.

This prediction is borne out, as *likely* constructions allow for anaphoric reference to the embedded clause proposition, whether the complement is finite or non-finite.

(255) It's likely that Nancy was at the party. She told me *that*, and I don't think she has any reason to lie.

#*that:* It is likely that Nancy was at the party. MATRIX CLAUSE

✓*that:* Nancy was at the party. EMBEDDED CLAUSE

(256) Nancy was likely to be at the party. She told me *that*, and I don't think she has any reason to lie.

#*that:* Nancy was likely to have been at the party. MATRIX CLAUSE

✓*that:* Nancy was at the party. EMBEDDED CLAUSE

(257) It's unlikely that Barb will be at the party. Dustin told me *that*'s true, but he's always lying.

#*that:* It's unlikely that Barb will be at the party. MATRIX CLAUSE

✓*that:* Barb will be at the party. EMBEDDED CLAUSE

(258) Barb is unlikely to be at the party. Dustin told me *that*'s true, but he's always lying.

#*that:* Barb is unlikely to be at the party. MATRIX CLAUSE

✓*that:* Barb will be at the party. EMBEDDED CLAUSE

In (255), it would be very strange for Nancy to have spoken only about the probability of her own past behavior (and not to simply say what she did), so the reading of the anaphor as referring to the matrix clause proposition is infelicitous. The only felicitous reading of (255) is that Nancy told the speaker she was in fact at the party, which makes *that* refer to the proposition associated with the embedded finite clause. (256) is exactly the same, only with a non-expletive subject and a non-finite embedded clause, those changes not changing the anaphoric availability of the embedded clause proposition. (257) and (258)

use *unlikely*, have a future orientation, and have a liar in the follow-up, but their anaphoric behavior is unchanged. The follow-up in (257) presents a reason to deny the truth of the antecedent of *that*, which renders the matrix clause interpretation self-contradictory and thus infelicitous. The felicitous reading of (257), instead, has Dustin asserting that Barb will attend the party, which is the proposition associated with the embedded clause. The anaphor can refer to this content, which means there is a propositional discourse referent introduced for the embedded clause. ((258) behaves exactly in parallel.)

Likely constructions, regardless of the finiteness of their embedded clauses, allow for felicitous anaphoric reference to the propositions associated with those embedded clauses. This is in line with the Krifka 2013 proposal.

3.4.3 *Tough* constructions

Tough constructions are those which involve the word *tough*. Like the *likely* constructions seen above, *tough* constructions can appear with expletive subjects, and have also been argued to be a form of raising construction (either A-movement, Rosenbaum 1965, or A-bar movement, Chomsky 1977). Regardless of their derivation, the complement clause is taken to be a CP (Hicks 2009), which means under the Krifka 2013 proposal these constructions should allow for propositional anaphora to their embedded clause.

This prediction is not borne out, however, as *tough* constructions don't allow for anaphoric reference to the embedded clause.

(259) Moby Dick is tough for Dustin to read. I know *that* because I saw him reading it in the library and he only turned one page an hour. MATRIX CLAUSE

(260) # Moby Dick is tough for Dustin to read. I know *that* because I saw him in the library and it was open on the table in front of him. EMBEDDED CLAUSE

The follow-up in (259) biases a matrix clause interpretation, mentioning the slow pace as evidence for the book being tough. This discourse is felicitous, illustrating that anaphoric reference to the proposition denoted by the matrix clause is possible. The follow-up in (260) biases resolution of the anaphor towards the proposition associated with the embedded clause, namely 'Dustin read Moby Dick', because the book being open in front of him is good evidence of his reading (but not sufficient evidence to judge his difficulty). This discourse is infelicitous, which suggests that the embedded clause proposition is not available as an antecedent.

We can see the same behavior with an expletive subject.

(261) It's tough for Dustin to read Moby Dick. I know *that* because I saw him reading it in the library and he only turned one page an hour. MATRIX CLAUSE

(262) # It's tough for Dustin to read Moby Dick. I know *that* because I saw him in the library and it was open on the table in front of him. EMBEDDED CLAUSE

Tough constructions do license anaphoric reference with *that* and *it*, as in (263), but these don't involve reference to propositions.

(263) Moby Dick is tough for Dustin to read, but $\left\{ \begin{matrix} \textit{that}\text{'s} \\ \textit{it}\text{'s} \end{matrix} \right\}$ easy for Elle.

The anaphora in (263) involves reference to an event (reading Moby Dick is easy) or to an individual (Moby Dick is easy), but not to a proposition (*Jesse read Moby Dick is easy).

Tough constructions don't make a proposition associated with the embedded clause available for anaphoric reference. This runs contrary to the prediction of Krifka 2013, as these embedded clauses contain TPs and so should thus have associated propositional discourse referents.

3.4.4 Finite clauses

There are multiple ways to divide the space of possible embedded clauses. Following Karttunen's (1969) lead overall, I've been focusing on syntactic characterizations, hence non-finite vs. finite, and raising vs. control within the non-finite complement clauses. Within the space of finite clauses, the divisions are largely semantic ones, though, of course, semantic distinctions can map onto syntactic ones (e.g., see White et al. in press). Whether a verb is representational (i.e., represents a belief about the world, using White et al.'s (in press) term) has already been taken into account, as non-representational verbs reliably embed only non-finite clauses (White et al. in press). Within the set of representational verbs, then, we can divide further based on whether a verb entails the truth of its complement (i.e., is factive) or not.

Factives

Factive verbs entail the truth of their complements. The standard example is *know* (though see Wiegand 2015 on the non-factivity of focused *know*), but other examples include *doubt*, *prove*, *realize*, etc.

These sorts of verbs allow anaphoric reference to the propositions associated with their embedded clauses:

(264) Nancy knows (that) Steve threw a party. Barb told her *that*.

#*that:* Nancy knows Steve threw a party. MATRIX CLAUSE

✓*that:* Steve threw a party. EMBEDDED CLAUSE

(265) Nancy proved (that) Steve threw a party, so now I believe *that*.

#*that:* Nancy proved Steve threw a party. MATRIX CLAUSE

✓*that:* Steve threw a party. EMBEDDED CLAUSE

The anaphor *that* in (264) cannot be taken to felicitously refer to the proposition conveyed

by the matrix clause of the first sentence, because (absent an amnesia scenario) Barb does not have the authority to tell Nancy what Nancy knows. Instead, the felicitous interpretation of (264) is for the anaphor to refer to the proposition conveyed by the embedded clause, 'Steve threw a party'. Similarly, the matrix clause interpretation of (265) is ruled out by the follow-up: an assertion is not adequate evidence for itself (where *so* indicates a conequence), and a speaker presumably typically forms a belief prior to asserting it. The natural interpretation of (265) is for the speaker, having witnessed the proof, now believes that Steve threw a party—which is the embedded clause proposition. These factive predicates allow for anaphoric reference to their complement clause propositions; the same is true for *doubt* and *realize*, and the emotive factive *love*.

(266) Hopper remembered (that) Joyce was vegetarian even though she didn't tell him *that*.

(267) Nancy realized (that) Steve cared about her. She hadn't known *that*, and now it was crystal clear.

(268) Lucas loves that Nancy won the award. She told him *that* on Monday and he's been beaming ever since.

The contexts of these sentences make each matrix proposition an unsuitable antecedent, but each embedded clause proposition is perfectly appropriate and available for anaphoric reference.

The data above also cross-cut the White et al. in press feature of assertivity: *realize* is assertive, but *love* is not. That is to say, uttering a sentence with *realize* can be used to assert its complement, where the matrix content becomes backgrounded (see Simons 2007). Assertivity is also correlated with the ability of a verb to be slifted (Ross 1973), as non-assertive verbs like *love* can't be backgrounded, nor do they allow their complements to be slifted (White et al. in press). Nevertheless, both *realize* and *love*—and thus, both as-

sertive and non-assertive verbs—allow the proposition denoted by the embedded clause to be available for anaphoric reference.

Non-factives

Verbs which do not entail the truth of their (finite sentential) complements also make the propositions denoted by those complements available for anaphoric reference. This includes speech reports, as in (269), as well as other attitude reports, as in (270)–(272).

(269) Nancy said (that) Steve threw a party. Barb told her *that*.

#*that:* Nancy said Steve threw a party. MATRIX CLAUSE

✓*that:* Steve threw a party. EMBEDDED CLAUSE

(270) Nancy thought (that) Steve threw a party. Barb told her *that*.

#*that:* Nancy thought Steve threw a party. MATRIX CLAUSE

✓*that:* Steve threw a party. EMBEDDED CLAUSE

(271) Nancy supposed (that) Steve threw a party. Barb told her *that*.

#*that:* Nancy supposed Steve threw a party. MATRIX CLAUSE

✓*that:* Steve threw a party. EMBEDDED CLAUSE

(272) Nancy heard (that) Steve threw a party. Barb told her *that*.

#*that:* Nancy heard Steve threw a party. MATRIX CLAUSE

✓*that:* Steve threw a party. EMBEDDED CLAUSE

The discourses in (269)–(272) are bizarre on a reading where the anaphor *that* refers to the matrix clause proposition, as outside an amnesia context, Barb presumably does not have the authority to tell Nancy what Nancy said/thought/suppose/heard. (And, because the second sentence of each discourse is an explanation of the first, such an interpretation would require Nancy to say/think/suppose/hear on the *basis* of Barb's authority.) The matrix interpretation of each is unavailable, but these discourses still manage to be felic-

itous because there is an alternative antecedent available for the anaphor: the embedded clause proposition.

These also cross-cut another two characteristics discussed in White et al. in press: *say* is communicative and not perceptual, *hear* is perceptual and not communicative, and *think* is neither communicative nor perceptual.[48] Nevertheless, they all make available anaphoric reference to the proposition denoted by their complement clause.

Both factive and non-factive finite clauses conform to the Krifka 2013 generalization: the embedded clauses contain TPs, and they have associated propositional discourse referents. These TPs are not sensitive to the semantic character of the verb that embeds them, and introduce a propositional discourse referent regardless of the factive, assertive, communicative, or perceptual status of the embedding verb.

Slifting constructions

Slifting constructions are those where, as described by Ross 1973, an embedded sentence is lifted (sentence-lifted, or slifted) to a higher syntactic position, leaving what would have been the matrix embedding verb in a slifting parenthetical. (For Grimshaw 2011, the slifted clause is the main clause, and the slifting parenthetical is an adjunct. For now, I use Ross's (1973) term but take no stance on the syntactic derivation of these constructions.) For example, compare the embedding construction in (269), repeated in (273), to its slifted counterpart in (274).

[48] White et al. in press characterizes *hear* as factive, but I think this is mistaken. A normal use of *hear* as in (x) may give rise to the presumption of the truth of its complement, but this implication is defeasible (as in (xi)a) in a way that is not available to truly factive verbs (as in (xi)b–c).

(x) Dustin heard (that) there was a party last night.

(xi) a. Dustin heard (that) there was a party last night, but that's not true. (There was no party.)
b. # Dustin hated that there was a party last night, but that's not true. (There was no party.)
c. # Dustin discovered (that) there was a party last night, but that's not true. (There was no party.)

(273) Nancy said (that) Steve threw a party. =the first sentence of (269)

(274) Steve threw a party, Nancy said.

Slifting parentheticals differ from their matrix counterparts in several ways noted in the literature: they usually cannot host negation (Ross 1973 and others); they do not allow some normal embedding predicates or are restricted in person or tense (Ross 1973; Reinhart 1983; Simons 2007); they do not allow for adverbial modification (Simons 2007); and they usually cannot modify subordinate clauses, where normal embedding verbs can be multiply embedded (Koev 2016).

To this list, we can add differing behavior for propositional anaphora: where a normal embedding sentence like (269) makes both the embedded clause proposition and the matrix clause proposition available for anaphoric reference, a slifting construction like (274) does not. Consider (275), which tests the anaphoric potential of (274).

(275) Steve threw a party, Nancy said. But Barb doesn't believe *that*.

#*that:* Nancy said Steve threw a party. SLIFTED PARENTHETICAL

✓*that:* Steve threw a party. 'EMBEDDED' CLAUSE

The proposition denoted by the first clause of (275), 'Steve threw a party'—which would be the embedded clause in a normal embedding construction—, is a possible antecedent of the anaphor *that*. The proposition conveyed by the slifted parenthetical is not an available antecedent: we cannot understand (275) to mean that Barb doesn't believe Nancy said something.

We can see the contrast between slifting constructions and ordinary embedding constructions in (276).

(276) a. Nancy said Steve threw a party. He told me *that* and then laughed. I didn't get the joke.

b. # Steve threw a party, Nancy said. He told me *that* and then laughed. I didn't get the joke.

In a context where the person named Nancy uses the pronoun *she* and not *he*, the embedding construction in (276a) allows for felicitous anaphoric reference to the 'Nancy said…' proposition. The slifting construction in (276b) does not.

Murray 2014 calls the proposition conveyed by an English slifted parenthetical the evidential proposition, drawing a parallel with the propositions conveyed by Cheyenne evidentials. On that account, Cheyenne evidential propositions are not assigned propositional discourse referents, and Murray 2014 suggests the same for English slifting constructions. The data here support this proposal: an English slifting construction introduces only one propositional discourse referent, for the 'embedded' clause proposition; no discourse referent is introduced for the evidential proposition, as it is not available for anaphoric reference. Slifting constructions have different anaphoric properties from embedding constructions, even those that use the exact same words.

3.4.5 Relative clauses

Relative clauses are clauses which modify a head, conveying some information about the head. In the case of restrictive relative clauses, the head must be a noun phrase, and the added information shrinks the set of possible referents being discussed, as in (277). Non-restrictive relative clauses add information about the entire (possibly singleton) set and don't reduce it, as in (278).

(277) [There are twenty students in my class.]

The two students who performed the worst in the class may retake the exam.

(278) [There are two students in my office.]

The two students, who performed the worst in the class, are retaking the exam.

In addition, non-restrictive relative clauses can modify structures other than noun phrases, as in (279) (examples and labels from Arnold & Borsley 2008: (14), (17); see also Jackendoff 1977; Fabb 1990; Arnold 2004):

(279) a. Kim owns a dog, which is regrettable. S

b. Kim owns a dog, which is a dachshund. NP

c. They have done the washing, which they said they would. VP

d. They hid the books under the bed, which is a good place. PP

e. They painted the house red, which is a nice colour. AP

f. They dressed carefully, which is also how they talk. ADVP

There is significant debate about the structural analysis of relative clauses (see, e.g., discussion in De Vries 2006). Across these analyses, however, both restrictive and non-restrictive relative clauses are considered to be full CP structures (e.g., Bhatt 2002), so Krifka 2013 predicts that they should be available for propositional anaphoric reference.

Restrictive relative clauses

In many cases, the proposition conveyed by a restrictive relative clause (RRC) is hard to make anaphoric reference to, as the proposition conveyed by the matrix clause is so much more prominent (being the main point of the utterance, and usually also more recent). The discourses in (280) & (281), for example, attempt to bias interpretation in favor of anaphoric reference to the RRC proposition, but end up being degraded.

(280) The pair of pants that Lucas wanted was sold out, but Elle didn't believe *that*. She didn't think they were his style.

#*that:* The pants were sold out. MATRIX CLAUSE

?*that:* Lucas wanted that pair of pants. EMBEDDED CLAUSE

(281) The student who cheated on the test met with Principal Coleman today. He doesn't know *that*, though, so he didn't punish him.

?*that:* The student met with Principal Coleman today. MATRIX CLAUSE

?*that:* The student cheated on the test. RELATIVE CLAUSE

In (280), the follow-up explains why Elle didn't believe the antecedent proposition, and that explanation is incompatible with the matrix clause—Lucas's style doesn't change what is sold out—so the anaphor cannot be interpreted as referring to the matrix proposition. The follow-up explanation *does* provide a reason that Elle might disbelieve the RRC proposition—that Lucas wanted that pair of pants—but this reading seems unavailable or at least fairly degraded. Similarly, the context of (281) makes the matrix clause proposition a bizarre antecedent for *that* to refer to: presumably the principal knows who he met with. What the principal might not know, and might have otherwise merited punishment, is the proposition 'the student cheated on the test', which is conveyed by the RRC. This proposition doesn't seem to be easily available for anaphoric reference in (281), though, as the discourse on the whole is degraded.

There are cases, however, where RRCs do make the propositions they denote available for anaphoric reference. In particular, these are cases where the referring anaphor is in the matrix clause, as in (282):

(282) Every student who cheated on the test told their mother $\left\{\begin{array}{l} \textit{that} \\ \textit{so} \\ \textit{as much} \end{array}\right\}$.

✓*that/so/as much:* They cheated. RELATIVE CLAUSE

Each student in (282) needn't have told their mother anything about other students for the sentence to be felicitous: the anaphor needn't refer to the matrix 'every student' proposition. The sentence is felicitous even if each student x tells x's mother only about x's own behavior, that is, if the anaphor refers to the proposition denoted by the RRC (bound under *every*). The RRC does have an associated propositional discourse referent, then, even if it was hard to refer to in (280) & (281).

If the anaphor is in a subsequent clause, though—even a conjoined clause, with no sentence break—. reference to the RRC becomes unavailable, even with a heavily biased context.

(283) a. Every student who cheated on the test got an A, but the teacher didn't believe *that*. She thought Steve cheated despite his getting a B.

b. # Every student who cheated on the test got an A, but the teacher didn't believe *that*. She couldn't believe Barb would ever cheat.

The follow-up in (283a) gives a reason that the teacher disbelieves that every student who cheated got an A, which is the proposition denoted by the matrix clause of the first conjunct. This is felicitous, unsurprisingly, as the matrix proposition is available for anaphoric reference. The follow-up in (283b), though, gives a reason that the teacher might disbelieve about a particular student that she cheated on the test, which is the proposition conveyed by the RRC. This discourse is infelicitous, demonstrating that the anaphor cannot refer to the RRC proposition: it does not have a propositional discourse referent which is available for reference in this second conjunct.

The propositions conveyed by RRCs are similarly unavailable for anaphoric reference from within an interrogative matrix clause. This is true both for a polar question, as in (284a), and for a *wh-* question, as in (284b).

(284) a. # Were the ingredients for those cookies (that) you made expensive? Because Joyce doubts *that*: she thinks they're store-bought.

b. # What did you put in those cookies (that) you made? Because Joyce doubts *that*: she thinks they're store-bought.

The polar question in (284a) allows for anaphora to the proposition 'The ingredients for those cookies (that) you made were expensive', as we saw in §3.3.2. The reading of (284a) we're interested in here, however, where *that* refers to the proposition conveyed by the RRC—'The addressee made those cookies'—is not felicitous. This is perhaps unsurprising: just as in (283b), there is a propositional discourse referent (associated with the matrix clause) which is 'competing' for anaphora resolution. More surprising from this perspective is (284b), where there is no such 'competitor': the matrix *wh-* interrogative doesn't introduce a propositional discourse referent (see §3.3.2) but the RRC proposition is nevertheless unavailable. RRCs (with declarative mood) embedded in matrix interrogatives (with interrogative mood) are not available for propositional anaphoric reference to an anaphor in a subsequent clause, just like RRCs embedded under matrix declaratives (as in (283b)).

There are some cases where the proposition conveyed by a RRC does appear to be accessible to an anaphor in a subsequent clause. In particular, these are cases where the matrix proposition carries minimal content, as in (285):

(285) All right. Now, here's a woman who has committed perjury. We know *that*. Plus, she says on these tapes, I've lied all my life. (COCA, Davies 2008–)[49]

In this example, the first sentence acknowledges the prior discourse and starts a new turn (not introducing any new propositional content), and the second sentence contains a RRC which appears to be the antecedent of the anaphor in the third sentence. The main

[49] 1998 (19980727). Investigating the President: Movement in Starr's White House Probe. *Crossfire*, CNN.

function of the second sentence is to establish the woman (Monica Lewinsky) as the topic of the following discourse, leading up to a question about her reliability as a witness. The matrix clause content of the second sentence—less the contribution of the RRC—amounts to 'a woman exists', which is old information in this context; it is the proposition conveyed by the RRC, namely that Lewinsky has committed perjury, which is the more relevant and potentially discourse-new information, and it is this proposition which the anaphor refers to. This appears to be a counterexample to the pattern that anaphoric reference to a proposition conveyed by a RRC is possible for an anaphor in the clause containing the RRC but impossible to anaphors in subsequent clauses. Because of the minimal content of the matrix clause, however, it is hard to differentiate between anaphoric reference to 'A woman has committed perjury' and 'Here is a woman who has committed perjury'. This may in fact be an example of anaphora from a subsequent clause to a RRC, or it may be better explained in some other way—e.g., as a continuation of the prior clause, or as reference to the matrix clause proposition. Even if it is, however, it does not reflect the overall trend, and so I put it aside for now.

Restrictive relative clauses do make a proposition available for subsequent anaphoric reference, but only in a limited fashion. Anaphors within the matrix clause containing the RRC can access this propositional discourse referent, but subsequent matrix anaphors—even those in later clauses connected via conjunction—cannot.

This is immediately reminiscent of a DRT approach to anaphora, where the accessibility of a discourse referent is sensitive to its relation to operators, e.g., a discourse referent introduced in the antecedent of a conditional is accessible to its consequent(but not vice versa). On this type of account, the propositional discourse referent introduced for a RRC must be accessible to the clause (the box) which contains it, but must not be accessible to the top-most box, the discourse as a whole, or else it would continue to be available for reference by subsequent anaphors, which we have observed is not the case. More-

over, under DRT, both conjunction and sentence concatenation are treated identically, as DRS-merge (see Muskens 1996), so it is not surprising that a further conjunct and a later sentence are equally unable to access the RRC propositional discourse referent for the first conjunct (presuming it is not part of the top-level universe of discourse referents).

This would be a departure from the normal way restrictive relative clauses are treated in DRT, however. Both Cormack 1992: 347 and Kamp & Reyle 1993: 81–83 argue for a flat treatment of restrictive relative clauses, one where the discourse referents and conditions introduced by the RRC are part of the matrix clause box. This might be accurate for individual discourse referents—which is what Cormack 1992 and Kamp & Reyle 1993 are interested in—but the same does not appear to be the case for propositional discourse referents.

This sort of behavior is not accounted for in Krifka 2013, which discusses neither relative clauses (of any sort) nor any limits on the availability of a discourse referent once it is introduced. In some sense, the prediction that a propositional discourse referent is introduced is confirmed, as a RRC contains a TP. However, more work would be needed to explain how the availability of that discourse referent is constrained under Krifka 2013 theory.

Non-restrictive relative clauses

Non-restrictive relative clauses (NRRCs) convey propositions which are available for anaphoric reference, and not just within the matrix clause:

(286) Steve, who cheated on the test, got an 100. But Nancy doesn't know *that*, she thinks he's just really smart.

#*that:* Steve got an 100 on the test. MATRIX CLAUSE

✓*that:* Steve cheated on the test. RELATIVE CLAUSE

(287) Dustin, whom Joyce had bet against, won the race. She told me *that* in confidence.

#*that:* Dustin won the race. MATRIX CLAUSE

✓*that:* Joyce bet against Dustin. RELATIVE CLAUSE

The matrix clause proposition of (286) is 'Steve got an 100 on the test', and the NRRC conveys the proposition 'Steve cheated on the test'. The follow-up contrasts what Nancy thinks—that Steve is really smart—with the antecedent proposition that she doesn't know; this makes the matrix proposition an unsuitable antecedent for the anaphor, as being smart is consistent with doing well on a test. The much more natural antecedent in the context of this follow-up is for *that* to refer to the proposition that Steve cheated: if Nancy knew that, she might not think he was so smart. The proposition conveyed by the NRRC is available for anaphoric reference, then, even with the anaphor in the following sentence.

Similarly, the follow-up in (287) makes the matrix interpretation of the first sentence an unsuitable antecedent: it is far more likely that Joyce would want to keep her betting against someone a secret than that she would tell the results of the race (whose results are more likely to be public information) in confidence. The matrix clause is not a suitable antecedent for the anaphor, but (287) still has a felicitous reading in which *that* refers to the proposition conveyed by the NRRC, namely 'Joyce bet against Dustin'.

Non-restrictive relative clauses make propositional discourse referents available for subsequent anaphoric reference. Unlike those of their restrictive cousins, the propositional discourse referents introduced for NRRCs can be referred to by later clauses, and not just within the clause containing them. This comports with the predictions of Krifka 2013, as NRRCs contain TPs.

3.4.6 Clauses in subject position

Clauses that appear in object position are considered to be embedded under the matrix verb, begin arguments of that verb; these are the sorts of constructions discussed above. But sentential clauses can also appear in subject position in English, if they are extracted from object position.

(288) a. Dustin napped.

b. It horrified Lucas that Dustin napped.

c. That Dustin napped horrified Lucas.

Because propositions, unlike individuals, are not agentive, this sort of clausal subject can only appear with certain verbs, in particular ones where the object is the experiencer of a psychological state (Levin's (1993) *amuse* verbs), such as *astonish*, *embarrass*, or *upset*.

These clausal subjects are CPs (or, if they are considered to be nominalized, contain CPs), and thus contain TPs, and so the Krifka 2013 proposal predicts that they should make propositions available for anaphoric reference. This prediction is borne out:

(289) That Nancy went to the party upset Jonathan. Barb told him *that*.

#*that:* Nancy's going to the party upset Jonathan. MATRIX CLAUSE

✓*that:* Nancy went to the party. SUBJECT CLAUSE

(290) That $\sqrt{2}$ is irrational confused Mike no matter how many ways Mr. Clarke proved *it* (to be true).

#*it:* $\sqrt{2}$'s being irrational confused Mike. MATRIX CLAUSE

✓*it:* $\sqrt{2}$ is irrational. SUBJECT CLAUSE

(291) That Steve finished in last place embarrassed him. His coach told him *that* yesterday, and he's been hiding in his room ever since.

#it: Steve's last place finish embarrassed him. MATRIX CLAUSE

✓*it:* Steve finished in last place. SUBJECT CLAUSE

In (289), Barb is unlikely to be a greater authority on Jonathan's emotions than he is, so it is bizarre for her to tell him what upsets him—this would be the interpretation if the anaphor were understood to refer to the matrix clause proposition. Instead, the more natural and felicitous interpretation of (289) is for Barb to have told Jonathan that Nancy went to the party—which is the proposition conveyed by the subject clause—, for Barb to have been the source of the news which in turn upset Jonathan. The subject clause in (289) makes the proposition it conveys available for anaphoric reference. We can see parallel behavior in (290) and (291): Mr. Clarke would have been proving the mathematical fact, not Mike's confusion; and Steve's coach would have told him about the race's results, not Steve's own reaction to them.

There are other clausal subjects which are similarly derived from the complement of a verb, but which cannot stand alone as complete sentences, and which are not propositional.

(292) a. It would upset Lucas for Dustin to leave.

b. For Dustin to leave would upset Lucas.

(293) a. It would be a big deal for Huckabee to endorse him.

b. [F]or Huckabee to endorse him would be a pretty big deal. (COCA)[50]

These future-oriented *for…to* clauses can appear as the complement of *hope* or *yearn* (Levin's (1993) *Long* verbs), but not *know* or *believe* or *doubt*. They describe events, not

[50]2011 (111127). Roundtable guests Rich Lowry of National Review; Jon Meacham, executive editor of Random House; presidential historians Doris Kearns Goodwin and Michael Beschloss; Michael Eric Dyson, author and professor. *Meet the Press*, NBC.

propositions. And, as such, they do not make a proposition available for anaphoric reference.

(294) # For Nancy to go to the party would upset Jonathan. Barb told him *that*.

(295) # For Nancy to go to the party would upset Jonathan. Barb would tell him *that*, and then he'd get angry.

(296) # For Steve to finish in last place would embarrass him. His coach told him *that*.

(297) # For Steve to finish in last place would embarrass him. His coach would tell him *that*, and he would hide in his room for a week.

Even with a follow-up with proper modal subordination (Roberts 1989), anaphoric reference to the subject clause is not licit.

The propositional content associated with a clause in subject position is available for anaphoric reference. This accords with the Krifka 2013 proposal, as these clauses include TPs.

3.4.7 Conditionals

Conditional statements describe a relationship between an antecedent (in English, usually an *if* clause) and a consequent (a *then* clause).[51] Syntactically speaking, English conditionals are biclausal: the antecedent is a subordinate clause, and the consequent is an independent clause. If each clause conveys a proposition, we might have two propositional discourse referents, as in (298). However, philosophers and logicians tend to talk about conditionals as having two parts of equal status, giving us the triclausal structure in (299). Under this view, we might expect conditionals to make three propositions available for anaphoric reference.

[51] Because the word *antecedent* is used for both anaphoric antecedents and conditional antecedents, I will be careful to say *conditional antecedent* when ambiguity might arise.

(298) $[\,[\,\text{antecedent}\,]_1\ \text{consequent}\,]_2$

(299) $[\,[\,\text{antecedent}\,]_1 \rightarrow [\,\text{consequent}\,]_2\,]_3$

The difference between these anaphoric predictions comes down to whether the consequent alone is available for reference, absent the relationship described by the conditional. Only the philosophers' approach (in (299)) could allow for such reference, as the consequent is independent of the matrix conditional statement. Under the syntactic approach, however, the matrix clause carries both the consequent and the conditional relationship, which are indivisible. Krifka 2013 does not comment on conditionals, but presumably would endorse the syntactic approach in (298): both antecedent and consequent contain TP, and so should make a propositional discourse referent available.

For most conditionals, it is hard to distinguish reference to the consequent from reference to the whole conditional, because a hearer is evaluating the truth of the consequent only within the antecedent worlds. That is to say, by the time we're thinking about the consequent, we are already taking the antecedent into account, and thus are effectively considering the whole conditional. For example, consider (300), where each follow-up attempts to force a different antecedent for the anaphor *that*:

(300) If Dustin goes to the party, (then) a fight will break out.

a. # But Elle doesn't believe *that*; she thinks Dustin will stay at home.

b. ? But Elle doesn't believe *that*; she thinks everyone there is a pacifist.

c. But Elle doesn't believe *that*; she thinks everyone gets along with Dustin.

Each follow-up presents Elle's alternative belief which gives her reason to disbelieve the antecedent proposition referred to by the anaphor. (300a) contrasts with the conditional antecedent 'Dustin goes to the party', and this follow-up is infelicitous; this suggests that the conditional antecedent is not available for anaphoric reference. (300c) gives a reason

to disbelieve the relationship between antecedent and consequent conveyed by the entire conditional: if everyone gets along with Dustin, then his attending the party is unlikely to lead to a fight. This follow-up is felicitous, which indicates that anaphoric reference to the entire conditional is possible. (This does not yet distinguish between the schemas discussed above.) The follow-up in (300b) attempts to target just the consequent, 'A fight will break out', independently of the conditional antecedent. The interpretation of (300b), though, if felicitous, is not clearly distinguishable from that of (300c): the attendees' pacifism would explain their not getting into a fight just as much *with* Dustin's presence as in his absence.

We can pull these readings apart if we choose a consequent which is, at its face, less closely related to the conditional antecedent. These conditionals can be a little harder to parse out of the blue, specifically because the relation between antecedent and consequent is less clear. In a proper context, though, these are perfectly sensible (and contexts can almost always be cooked up which relate two seemingly disparate statements). For (301), for example, imagine that Dustin and Joyce are research partners, one of whom will need to get a book out from the library tomorrow.

(301) If Dustin goes to the party, (then) Joyce will go to the library.

a. # But Elle doesn't believe *that*; she thinks Dustin will stay home.

b. # But Elle doesn't believe *that*; she thinks Joyce will stay home.

c. But Elle doesn't believe *that*; she thinks they will stick together.

The follow-up and anaphor in (301a) attempt to target the conditional antecedent, but as in (300) fail to be felicitous. (301b) attempts to target just the consequent, giving Elle's alternative belief for what Joyce will do. Here, we get a clearer judgment of the infelicity of this follow-up. This is likely due to the (surface) independence of the consequent from the conditional antecedent. In (300), we understand the fight to be breaking out at [the

party (which Dustin might attend)];[52] in this sense, the interpretation of the consequent relies on the interpretation of the conditional antecedent in a way that (301) does not.[53] (301b) seems to contrast with just the consequent, independently of the conditional antecedent, and it is infelicitous. The consequent alone, then, is not a suitable antecedent for the anaphor *that*. The follow-up in (301c), which targets the conditional as a whole, is felicitous.

This behavior is not limited to future-oriented conditionals, nor to eventive predicates. We can see the same behavior with stative predicates both in the present, as in (302), and in the past, as in (303).

(302) If Dustin is at the party, (then) Joyce is at the library.

a. # But Elle doesn't believe *that*; she thinks Dustin is at home.

b. # But Elle doesn't believe *that*; she thinks Joyce is at home.

c. But Elle doesn't believe *that*; she thinks they go everywhere together.

(303) If Dustin was at the party, (then) Joyce was at the library.

a. # But Elle doesn't believe *that*; she thinks Dustin was at home.

b. # But Elle doesn't believe *that*; she thinks Joyce was at home.

c. But Elle doesn't believe *that*; she thinks they were together all day.

In all of these conditionals, neither the conditional antecedent nor consequent are available for subsequent propositional anaphoric reference. We can have felicitous anaphoric reference from a subsequent clause, but only if it is event anaphora:

[52]This is defeasible: in the right context, we might understand the fight to be elsewhere, e.g., if his parents are at home fighting about whether he should have been allowed to go.

[53]Our temporal interpretation of the consequent may be taken to rely on the that of the conditional antecedent, in that a natural of reading of (301) has Joyce at the library at the same time that Dustin is at the party (see Partee 1973). However, this too is defeasible: we can understand (301) as meaning 'If Dustin goes to the party tonight, then Joyce will go to the library next week'. Such a meaning might require a little more contextual work, but it is not impossible.

(304) If Dustin goes to the party, (then) Joyce will go to the library.

a. But Elle doesn't think *that* will happen; she thinks Dustin will stay home.
EVENT ANAPHORA

b. But Elle doesn't think *that* will happen; she thinks Joyce will stay home.
EVENT ANAPHORA

Conditional antecedents do make propositional discourse referents available, however, for anaphoric reference from within the consequent.

(305) If Nancy is at the party, then Steve will want to know *that*.

✓*that:* Nancy is at the party.

(306) If Mike cheated on the test, then his mother already knows (*that*).

✓*that/∅:* Mike cheated on the test.

And, this internal availability can be extended to subsequent clauses which are modally subordinate (Roberts 1989, see also Frank 1997; Geurts 1999).

(307) If Nancy is at the party, then Steve will want to know *that*. Lucas will want to know *that*, too.

✓*that:* Nancy is at the party.

(308) If Dustin was at the party, then Joyce was at the library. But Elle wouldn't have believed *that*, anyways; she thought they were inseparable.

✓*that:* Dustin was at the party.

This is similar to what we observed for restrictive relative clauses in §3.4.5, where a propositional discourse referent was introduced, but only available within a limited domain. And, as discussed there, this is reminiscent of a DRT treatment of discourse referents; in fact more so here, as DRT allows (individual) discourse referents introduced in the an-

tecedent of a conditional to be accessible to conditions in the consequent. However, just as with restrictive relative clauses, the DRT analysis of individual discourse referents in conditionals cannot be perfectly extended to propositional discourse referents.

In DRT, the accessibility relationship of a conditional is unidirectional: the antecedent is accessible to the consequent, but not vice versa. However, just as the conditional antecedent proposition is available for an anaphor in the consequent in (305), so too is the consequent available for (cataphoric) propositional anaphora from within the conditional antecedent.

(309) If Einstein believes *it*, then $\sqrt{2}$ is irrational.

✓*it:* $\sqrt{2}$ is irrational.

(310) If Trump doubts *it*, then climate change is real.

✓*it:* Climate change is real.

The consequent (independent of the antecedent) is available for anaphoric reference if the anaphor is within the conditional antecedent. This extends beyond what DRT allows for individual discourse referents, and suggests that propositional discourse referents are subject to different accessibility constraints. Examples like (309) also illustrate that the consequent can be distinguished from the conditional as a whole, as the anaphor *it* surely does not refer to the larger structure containing it. That the consequent is ever differentiable from the conditional as a whole also suggests that we should prefer a philosophical approach to conditionals (as in (298)) over a syntactic one (as in (298)).

In summary, conditional antecedents and consequents make propositions available for anaphoric reference, but only from within a given conditional. Neither antecedent nor consequent proposition is available for anaphoric reference from a subsequent clause, even if that clause is discourse subordinate to the conditional. The matrix conditional proposition, however, remains available to subsequent clause anaphors, which is in line

with general matrix clause behavior as observed thus far. That the antecedent and consequent introduce propositional discourse referents is in line with the Krifka 2013 proposal, but the limited availability of those discourse referents requires constraints or further mechanisms not discussed in Krifka 2013.

3.4.8 Sentential adverbs

Sentences with sentential adverbs like *only* or *even* convey multiple propositions.

(311) Only $[$ the Red Sox $]_F$ can beat the Yankees. (Ippolito 2006: (1))

(311) conveys two propositions: the prejacent proposition, that the Red Sox can beat the Yankees, and the exclusive proposition, that the Red Sox are the only ones who can do so. Much has been written about the status of these two propositions. It is generally agreed that the exclusive proposition is the primary content of such a sentence and is asserted, but the prejacent proposition has been argued variously to be asserted (Atlas 1993), presupposed (Horn 1969, 1996; Geurts & Van der Sandt 2004), conversationally implicated (McCawley 1981), or derived from the presupposition of a scalar proposition (Ippolito 2006, following Rooth 1992, 1996).[54] In this section, we will look at the anaphoric availability of these propositions.

Because these sentential adverbs attach high in the syntax, the Krifka 2013 proposal predicts that the prejacent propositions of these adverbs should be available for anaphoric reference. The clauses that convey them, modified by these adverbs, contain TPs, and those TPs should introduce propositional discourse referents for the propositions they convey.

[54] It has also been argued to be an illusion, and not a sentence implication at all (Geach 1962).

Only

In the examples that follow, we'll be focusing on the focus-sensitive exclusive operator *only*, not the discourse connective *only* (which does not associate with focus). *Only* conveys a main exclusive proposition, as well as the prejacent proposition, as discussed above. The prejacent proposition is not available for anaphoric reference.

(312) Only the Red Sox can beat the Yankees.

a. Dustin doesn't believe *that*, though; he thinks the Orioles can, too.
MATRIX CLAUSE

b. # Dustin doesn't believe *that*, though; he thinks the Yankees are unbeatable.
PREJACENT

(313) [In a class of 200 students:]
Only Nancy failed the exam.

a. The professor told me *that* in confidence, though, so don't tell anyone.
MATRIX CLAUSE

b. ?? She told me *that* in confidence, though, so don't tell anyone. PREJACENT

(314) Only Nancy failed the exam.

a. She doesn't believe *that*, though; she thinks Dustin failed, too.
MATRIX CLAUSE

b. # She doesn't believe *that*, though; she thinks she aced it. PREJACENT

In (312a), the follow-up contrasts with the exclusive proposition conveyed by the matrix *only* clause: it's not just the Red Sox, as the Marlins can, too. This follow-up is felicitous, illustrating that the main clause proposition is available for anaphoric reference. In (312b), however, the follow-up contrasts with the prejacent proposition, and the resulting discourse is infelicitous. This suggests that the prejacent proposition is not an available

antecedent for the anaphor in (312b). We can see the same behavior in (313), whose context is such that the professor, but not Nancy, would have access to knowledge of the exclusive proposition. In (313a), then, citing the professor as the source of the exclusive proposition (targeted by the anaphor) is reasonable, and the discourse is felicitous. (313b) attempts to bias resolution of the anaphor towards the prejacent proposition, as Nancy would be a dependable source for that information (on her own performance), but would be unlikely to know about the entire class's performance. This discourse in highly marked, though, as the only possible interpretation is such that Nancy *does* in fact know about everyone's exam grades. The matrix clause proposition is the only possible antecedent for the anaphor; the prejacent proposition is not available for anaphoric reference.

Even

Sentences with the sentential adverb *even* are thought to convey two or three propositions.

(315) Even Steve can lift this box.

The sentence in (315) means (i) that Steve can lift the box in question—the prejacent proposition—, and (ii) that the information in (i) is maximally informative (Kay 1990)/noteworthy (Herburger 2016), i.e., because Steve is among the least likely to lift the box (e.g., because he is exceptionally weak)—the scalar proposition.[55] Some also posit that a sentence like (315) also means (iii) that someone other than Steve can lift the box—an existence/non-uniqueness implication—, though this has been argued to be derived by pragmatic inference (Herburger 2016).

Of these three propositions, only the prejacent proposition is available for anaphoric

[55]So called because *even* locates its associate towards the end of a relevant scale (see, e.g., Rullmann 1997. Additionally, it is worth pointing out that this position on the scale is a relative, not absolute (Kay 1990; Schwenter & Vasishth 2000).

reference.

(316) Even Nancy failed the exam.

a. She doesn't believe *that*, though; she thinks she aced it. PREJACENT

b. # She doesn't believe *that*, though; she thinks she's among the worst in the class. SCALAR

c. # She doesn't believe *that*, though; she thinks she was the only one. EXISTENCE

(317) Even the Phillies can sell out a stadium.

a. Dustin doesn't believe *that*, though; he thinks they simply can't. PREJACENT

b. # Dustin doesn't believe *that*, though; he thinks they're one of the few teams that can. SCALAR

c. # He doesn't believe *that*, though; he thinks they're the only team that can. EXISTENCE

Each follow-up in (316) provides an explanation which contrasts with one of the three propositions conveyed by the *even* sentence. In (316a), *she thinks she aced it* contrasts with the prejacent proposition, 'Nancy failed the exam'. This follow-up is felicitous, which indicates that the prejacent is an available antecedent for the anaphor *that*. In (316b), the follow-up contradicts the scalar proposition: if Nancy is among the worst in the class, then it is not noteworthy that she failed an exam. This follow-up is infelicitous, which suggests that the scalar proposition is not available for anaphoric reference. Similarly, the follow-up in (316c) is infelicitous. This follow-up contrasts with the existence implication: if she is the only one (who failed), then no other student failed. The infelicity of this follow-up suggests that the existence implication is not available for anaphoric reference.

(317) has a present-tense ability statement, as opposed to a past-tense event, but the

behavior is the same. The only propositional discourse referent introduced by the first sentence of (316) which is available for anaphoric reference is the one associated with the prejacent, 'The Phillies can sell out a stadium'.

Even, then, does not make any additional propositional discourse referents available for subsequent reference. The prejacent proposition is available, but neither the scalar implication nor the existence implication have associated propositional discourse referents.

3.4.9 Embedded interrogatives

Just as declaratives can be embedded within a clause, so can interrogatives. Just as in §3.3.2, we'll consider each type of interrogative individually. And, as discussed in that section, we'll pay close attention to the verb *doubt*, which takes propositional arguments but not interrogative ones (Ginzburg 1993: 278, fn. 10).

We will discuss only embedded interrogatives in object position, leaving aside subject interrogatives, as §3.4.6 suggests that clauses in subject position behave no differently than in object position.

Embedded polar questions

Polar questions can be embedded under *if*-clauses, or under *whether*-clauses (without an accompanying *or*). As we saw in §3.3.2, matrix polar questions introduce a propositional discourse referent for the proposition that partitions the answer space (but not for its complement). As such, we might expect the same to be the case for embedded polar questions; that, however, is not the case.

(318) Nancy knows if Barb was at the party, but Lucas doesn't know *that*.

✓*that:* Nancy knows if Barb was at the party.	MATRIX CLAUSE
✓*that:* Was Barb at the party?	POLAR Q
#*that:* Barb was at the party.	PARTITIONING PROPOSITION

(319) Nancy knows if Barb was at the party, but Lucas doubts *that*.

✓*that:* Nancy knows if Barb was at the party.	MATRIX CLAUSE
#*that:* Was Barb at the party?	POLAR Q
#*that:* Barb was at the party.	PARTITIONING PROPOSITION

With *know* in (318), the anaphor *that* can be taken to refer to either the proposition denoted by the matrix clause, or to the (true answer to the) question conveyed by the embedded *if*-clause. It can't be taken to refer specifically to the partitioning proposition 'Barb was at the party', unless the speaker knows that to be the truth; if the speaker knows that Barb actually was at the party, then knowing the partitioning proposition is indistinguishable from knowing (the true answer to) the embedded question.[56] With *doubt* in (319), though, the only possible antecedent for *that* is the proposition denoted by the matrix clause of the first sentence. The *if*-complement doesn't make a proposition available for anaphoric reference.

We can see the same behavior in *whether*-complements, which also don't make a proposition available for anaphora.

(320) Nancy knows whether Barb was at the party, but Lucas doesn't know *that*.

✓*that:* Nancy knows whether Barb was at the party.	MATRIX CLAUSE
✓*that:* Was Barb at the party?	POLAR Q
#*that:* Barb was at the party.	PARTITIONING PROPOSITION

(321) Nancy knows whether Barb was at the party, but Lucas doubts *that*.

✓*that:* Nancy knows whether Barb was at the party.	MATRIX CLAUSE
#*that:* Was Barb at the party?	POLAR Q
#*that:* Barb was at the party.	PARTITIONING PROPOSITION

[56] If the speaker knows that to be the truth, then using *knows that* instead of *knows if* would be preferable, unless they were trying to be coy.

With both *if*- and *whether*-clauses, embedded polar interrogatives do not make a proposition available for anaphoric reference. This is perhaps surprising, because matrix polar interrogatives *do*. This also presents another challenge to the Krifka 2013 proposal, as the TP under an interrogative is presumably the same whether that interrogative is itself embedded or is a matrix clause. As such, Krifka 2013 would seem to predict that that TP should introduce a propositional discourse referent in both cases. As we have observed, though, this is not the case: a matrix polar interrogative introduces a propositional discourse referent that an embedded polar interrogative does not.

Embedded *wh*- questions

As we saw in §3.3.2, matrix *wh*- questions do not introduce propositional discourse referents, so it is unsurprising that embedded *wh*- questions also do not.

(322) Barb knows who was at the party, but Mike doesn't know *that*.

✓*that:* Barb knows who was at the party. MATRIX CLAUSE

✓*that:* $\{x \mid x$ was at the party$\}$ TRUE ANSWER

(323) Barb knows who was at the party, but Mike doubts *that*.

✓*that:* Barb knows who was at the party. MATRIX CLAUSE

#*that:* $\{x \mid x$ was at the party$\}$ TRUE ANSWER

While *know* can take as an argument either the proposition denoted by the matrix clause, or the (true answer to the) interrogative, *doubt* can only apply to the matrix clause proposition. With *doubt* in (323), the anaphor can only refer to the matrix clause proposition, as the embedded *wh*- complement does not make a proposition available for anaphoric reference.

Embedded alternative questions

As we saw in §3.3.2, matrix alternative questions don't introduce propositional discourse referents, regardless of whether the alternatives are nominal or sentential, and even if one of the alternatives is the negation of the other. As with matrix alternative questions, we will be careful to control for intonation, lest the utterance be interpreted as a polar question. And, like matrix alternative questions, embedded alternative questions presuppose that exactly one of the alternatives is true (Biezma & Rawlins 2012).

As with matrix alternative questions, embedded alternative questions do not introduce a propositional discourse referent: not for the exhaustivity presupposition, nor for either of the alternatives.

(324) Elle knows whether Mike would like coffee$^{\uparrow}$ or tea$^{\downarrow}$, but Dustin doubts *that*.

✓*that:* Elle knows whether Mike would like coffee or tea.	MATRIX CLAUSE
#*that:* Mike would like coffee or tea.	PRESUPPOSITION
#*that:* Mike would like coffee.	LEFT DISJUNCT
#*that:* Mike would like tea.	RIGHT DISJUNCT

(325) Elle knows whether Mike would like coffee$^{\uparrow}$ or he'd prefer tea$^{\downarrow}$, but Dustin doubts *that*.

✓*that:* Elle knows whether Mike would like coffee or would prefer tea.	MATRIX CLAUSE
#*that:* Mike would like coffee or would prefer tea.	PRESUPPOSITION
#*that:* Mike would like coffee.	LEFT DISJUNCT
#*that:* Mike would prefer tea.	RIGHT DISJUNCT

(326) Elle knows whether Mike would like coffee$^{\uparrow}$ or not$^{\downarrow}$, but Dustin doubts *that*.

✓*that:* Elle knows whether Mike would like coffee or tea.	MATRIX CLAUSE
#*that:* Mike would like coffee or not.	PRESUPPOSITION
#*that:* Mike would like coffee.	LEFT DISJUNCT
#*that:* Mike would not like coffee.	RIGHT DISJUNCT

Regardless of the nature of the alternatives, propositional anaphora is licensed only to the matrix clause. The alternative question does not make any additional proposition available for anaphoric reference. Expanded contexts which attempt to bias each alternative, as in (218), are not provided here, but do not change the anaphoric availability of any alternative proposition.

3.4.10 Embedded imperatives

In §3.3.3, we observed that matrix imperatives don't introduce propositional discourse referents. Unsurprisingly, the same is true of embedded imperatives.

(327) Steve told me 'Shut the door!' but I don't believe *that*.

#*that:* Steve told me 'Shut the door!'	MATRIX CLAUSE
#*that:* Speaker should shut the door.	IMP∼MODAL
#*that:* The door is shut.	RESULT STATE

(328) Steve told me to shut the door but I don't believe *that*.

#*that:* Steve told me to shut the door.	MATRIX CLAUSE
#*that:* Speaker should shut the door.	IMP∼MODAL
#*that:* The door is shut.	RESULT STATE

(327) is a quotational embedded imperative, and (328) is a disquotational embedded imperative. In both cases, the Moore's frame (*but I don't believe that*) rules out interpreting the

anaphor as referring to the proposition denoted by the matrix clause. This renders both (327) & (328) infelicitous, as there are no other available propositional discourse referents. Anaphora is not licensed to either the imperative clause, nor to the result state.

In §3.3.3, we also contrasted matrix imperatives with modals sentences, noting that they have different anaphoric properties. The same demonstration can be made with embedded imperatives, contrasting (328) with (329)

(329) Steve told me I should shut the door but I don't believe *that*.

#*that:* Steve told me I should shut the door.	MATRIX CLAUSE
✓*that:* Speaker should shut the door.	EMBEDDED MODAL CLAUSE
#*that:* The door is shut.	RESULT STATE

The embedded modal declarative in (329) allows for felicitous anaphoric reference to the embedded modal proposition, while embedded imperatives do not.

A summary of the observations made about multiclausal constructions in this section is presented in Table 3.

Table 3: Multiclausal constructions

Construction			Introduce Propositional Discourse Referent?
Non-finite clauses	Raising	Subject raising	yes (232)
		Object raising	some (238b)
	Control	Subject control	some (244)
		Object control	no (249)
Likely constructions			yes (255)
Tough constructions			no (260)
Finite clauses	Factives		yes (264)
	Non-factives		yes (269)
	Slifted clauses		yes (275)
	Slifting parentheticals		no (276b)
Relative clauses	Restrictive		limited (282)
	Non-restrictive		yes (286)
Subject clauses	*that*-clauses		yes (289)
	for-clauses		no (295)
Conditionals	Antecedents		limited (305)
	Consequents		limited (309)
Sentential adverbs	*only*	Prejacent	no (312b)
		Exhaustive	yes (312a)
	even	Prejacent	yes (316a)
		Scalar	no (316b)
		Existence	no (316c)
Embedded interrogatives	Polar	*if*-clause	no (319)
		whether-clause	no (321)
	wh-		no (323)
	Alternative		no (326)
Embedded imperatives			no (328)

3.5 Multisentential constructions

In this section, we'll look at constructions which combine multiple independent sentences. In particular, we'll be looking at conjunction and disjunction.

3.5.1 Conjunction

A conjunction of two declarative sentences (which denote the propositions p and q) could give rise to as many as three propositional discourse referents: one for p, one for q, and one for $p \wedge q$.

Anaphoric reference to the proposition associated with the matrix conjunction is felicitous:

(330) A water main burst and they closed off the highway. The announcer said *that* on the radio.

The radio announcer is understood to have reported on both the mater main and the highway, so the anaphor *that* must refer to a discourse referent associated with the matrix conjunction. This is an unsurprising result, given the behavior of declarative matrix clauses we have observed thus far.

Anaphoric reference is also available to the right conjunct. The conjunction in (331) is a variant of an example from Asher & Vieu 2005 attributed to Caroline Heycock:

(331) John fell, and it was Christina who pushed him. He didn't know *that*, though.

In this discourse, the natural interpretation is for John (the referent picked out by *he*) not to know that it was Christina who pushed him. He presumably knows that he fell, but not who is responsible. Now, the nature of conjunction is such that because John doesn't know [Christina pushed him], he also doesn't know [he fell and Christina pushed him]. That said, speakers have the strong judgment that in (331) what John didn't know is the proposition denoted by the right conjunct, not that of the matrix conjunction.

We can see the same thing in (332), where the matrix conjunction isn't a plausible

alternative:

(332) [At a magic show, audience members are asked to secretly pick cards from a deck. After picking her card, Nancy whispers her choice to Jonathan, and then returns to her seat without talking to anyone else. Before the magician begins, Jonathan whispers to Sam:]

> The trick is about to begin, and Nancy has the three of hearts. She told me *that* in confidence, though, so keep it to yourself!

The context of (332) is such that we know Nancy to have told Jonathan only the content of the right conjunct, and not the matrix conjunction. In addition, the information conveyed by the left conjunct is more or less public, is not information that Nancy would have told in confidence, and also is *temporal* information which Nancy might not have had access to at the time of her utterance.[57] Instead, we understand the anaphor *that* to pick out the proposition denoted by the right conjunct: 'Nancy has the three of hearts'. The right conjunct, then, has an associated propositional discourse referent which is available for subsequent anaphoric reference.

[57]She could perhaps have said something like *When the magician takes out a handkerchief, the trick is about to begin*, but this is not information an audience member is likely to have; more importantly, it is not understood to be part of the antecedent of *that*.

The same is not true for the left conjunct, however:

(333) [At a magic show, audience members are asked to secretly pick cards from a deck. After picking her card, Nancy whispers her choice to Jonathan, and then returns to her seat without talking to anyone else. Before the magician begins, Jonathan whispers to Sam:]

?? Nancy has the three of hearts, and the trick is about to begin. She told me *that* in confidence, though, so keep it to yourself!

Speakers judge the discourse in the context of (333) to be degraded, or to mean that Nancy must have told Jonathan not only about her card but also about the timing of the trick (which has its own oddities, as discussed above). That is to say, either the discourse is infelicitous, or the anaphor is understood as referring to the matrix conjunction. (This depends, in part, on whether speakers are willing to 'enrich' the context given, adding to what Nancy told Jonathan beyond what was stipulated.) Even though the scenario biases a reading where the anaphor should refer to just the left conjunct content, it cannot be felicitously interpreted that way. The left conjunct is not available for subsequent anaphoric reference beyond the scope of the conjunction.

Anaphoric reference to the left conjunct *is* available from within the right conjunct, however:

(334) Steve got an A on the exam, and he told his mom $\left\{\begin{matrix} \textit{that} \\ \textit{so} \\ \textit{as much} \end{matrix}\right\}$.

(335) Joyce won the lottery, but she couldn't believe $\left\{\begin{matrix} \textit{that} \\ \textit{it} \end{matrix}\right\}$

We can understand the unavailability of anaphoric reference to the left conjunct after the conjunction is completed by thinking about the right frontier (Polanyi 1988, e.g., as formalized in Lascarides & Asher 2008). If syntactic conjunction via *and* or *but* requires

a discourse coordination relation between the two conjuncts (Asher & Vieu 2005), then conjunction always advances the right frontier. In doing so, discourse referents not in the right frontier (including, here, non-rightmost discourse units in coordination relations) become no longer available for anaphoric reference (see Lascarides & Asher 2008). Before the right conjunct has been computed, though, the left conjunct is still part of the right frontier, and so remains available for anaphoric reference.

All three propositions associated with a sentence conjunction are available for anaphoric reference, but to differing extents. The left conjunct is quickly subject to exclusion from the right frontier, and so is only available for anaphoric reference from within the right conjunct. The right conjunct, however, remains available for anaphoric reference from subsequent sentences, as does the matrix conditional proposition.

3.5.2 Disjunction

Disjunction, just like conjunction, can be thought of as connecting two propositions and, in doing so, creating a third. And, just like conjunction, all three of these propositions have associated discourse referents which are available for anaphoric reference.

The matrix disjunctive proposition is available for subsequent anaphoric reference, as in (336).

(336) [Nancy's birthday is approaching.]
Jonathan will buy Nancy flowers or he'll buy chocolates. She doesn't know *that*, though.

The right disjunct is available as well:

(337) Steve cheated on the test, or he got really lucky. He told the whole class *that*, but I don't quite believe him.

(338) Steve got really lucky on the test or he cheated. His mother hopes *that*'s not true.

For the left disjunct, reference is possible from within the right disjunct, as in (339), but is not available from subsequent sentences, as in (340)–(341).

(339) Either Joyce won the lottery, or she wants everyone to believe $\left\{\begin{array}{l} \textit{that} \\ \textit{so} \\ \textit{as much} \end{array}\right\}$.

(340) # Steve cheated on the test or he studied really hard, but his teacher hopes that's not true.

(341) # Steve studied really hard for the test or he cheated, and his teacher hopes that's true.

(339) suggests that Joyce has been spending extravagantly: she either won the lottery, or wants people to believe that she won the lottery. The anaphor can felicitously refer to the left disjunct. In (340), though, the left disjunct is not an available antecedent, even though it alone would make sense as a thing Steve's teacher might not want to be the case. The only reading available for (340) is that his teacher hopes he didn't study, which is a bizarre thing for a teacher to want, and so the discourse is infelicitous. The same is true for (341), which further demonstrates that the left disjunct is not available for anaphoric reference from subsequent sentences.

A summary of the observations made about multiclausal constructions in this section is presented in Table 4.

Table 4: Multisentential constructions

Construction		Introduce Propositional Discourse Referent?
Conjunction	Matrix clause	yes (330)
	Left conjunct	internally (334)
	Right conjunct	yes (332)
Disjunction	Matrix clause	yes (336)
	Left disjunct	internally (339)
	Right disjunct	yes (337)

3.6 Generalization and discussion

In the previous four sections, we have examined the availability of propositional anaphoric reference to a variety of constructions. A summary of all of the data we have observed is collected in Table 5.

Among the data most surprising are those regarding small clauses, whose anaphoric availability appears to depend upon the verb under which a small clause is embedded. Epistemic embedding verbs like *consider* make the proposition associated with the small available for anaphoric reference from subsequent clauses, but other embedding verbs do not. And we observed parallel behavior for adverbials: while it is surprising that any adverbials should introduce a propositional discourse referent, we saw that only epistemic adverbials do. This pattern continued—perhaps no longer surprising, but certainly still remarkable—with modal verbs as well, where epistemic modal verbs make their prejacent propositions available for subsequent anaphoric reference but root modals do not. Also notable were the data on interrogatives: only matrix polar interrogatives introduce a propositional discourse referent, but no *wh-* or alternative interrogatives do, nor do embedded polar interrogatives (with either *if-* or *whether-* complementizers).

Table 5: The anaphoric availability of a variety of constructions

Construction			Introduce Propositional Discourse Referent?
Subclausal	Names		no (131)
	Definites		no (132)
	Possessives		no (133)
	Intersective adjectives		no (136)
	Verbs with lexical presuppositions		no (139)
	Small clauses	Secondary Predication	no (141)
		Causative	no (144)
		Resultative	no (148)
		Epistemic	yes (150)
	Adverbials	Modifying DP	some (160)
		Modifying VP	some (167)
Declarative			
Matrix	Active		yes (169)
	Passive		yes (170)
Prejacent of	Negation	Sentential	yes (172)
		Constituent	no (173)
	Modals	Epistemic	yes (181)
		Deontic	no (183)
		Ability	no (189)
		Teleological	no (194)
		Bouletic	no (195)
		Metaphysical	no (198)
Interrogative	Polar		yes (202)
	wh-		no (209)
	Alternative	Nominal	no (218)
		Sentential	no (219)
Imperative			no (222)

Table 5, continued

Construction			Introduce Propositional Discourse Referent?
Non-finite clauses	Raising	Subject raising	yes (232)
		Object raising	some (238b)
	Control	Subject control	some (244)
		Object control	no (249)
Likely constructions			yes (255)
Tough constructions			no (260)
Finite clauses	Factives		yes (264)
	Non-factives		yes (269)
	Slifted clauses		yes (275)
	Slifting parentheticals		no (276b)
Relative clauses	Restrictive		limited (282)
	Non-restrictive		yes (286)
Subject clauses	*that*-clauses		yes (289)
	for-clauses		no (295)
Conditionals	Antecedents		limited (305)
	Consequents		limited (309)
Sentential adverbs	*only*	Prejacent	no (312b)
		Exhaustive	yes (312a)
	even	Prejacent	yes (316a)
		Scalar	no (316b)
		Existence	no (316c)
Embedded interrogatives	Polar	*if*-clause	no (319)
		whether-clause	no (321)
	wh-		no (323)
	Alternative		no (326)
Embedded imperatives			no (328)
Conjunction	Matrix clause		yes (330)
	Left conjunct		internally (334)
	Right conjunct		yes (332)
Disjunction	Matrix clause		yes (336)
	Left disjunct		internally (339)
	Right disjunct		yes (337)

Also surprising were the data surrounding the raising and control constructions which behaved far less uniformly than one might have anticipated. On a similar note, one might have expected tough constructions and likely constructions to behave similarly, and the same for sentential adverbs like *only* and *even*; but these, too, displayed unexpected differences. In this section, I will address these various behaviors, and present a generalization that captures these varied data. But first, it is worth returning to the proposal put forward in Krifka 2013.

Krifka 2013 proposed that TP and any projections above it (e.g., NegP for sentential negation) below the level of the speech act introduce a propositional discourse referent for the proposition denoted by that phrase. Throughout this chapter, we have found that this proposal has broad coverage, and accounts for the felicity of anaphoric reference to the prejacent of epistemic modals, likely constructions, factive and non-factive finite clausal complements, relative clauses, conditionals, and the constituent 'juncts of conjunction and disjunction. It also successfully predicts the infelicity of propositional anaphoric reference to a number of subclausal constructions which convey propositional content, as well as to prejacents of root modals,*wh-* questions, and possibly imperatives.

There are a number of constructions explored here which constitute challenges to the Krifka 2013 proposal, however. Epistemic small clause embedding verbs and epistemic adverbs do not include TPs, but make propositions available for anaphoric reference. And even noting the structural height distinction between epistemic and root modals (Cinque 1999; Hacquard 2011) does not immediately explain this behavior, unless all verbs and adverbs with epistemic flavor move up to an epistemic functional projection in the syntax. In addition, Krifka's (2013) proposal predicts that all embedded clauses in raising and control constructions—which include at least TPs, if not entire CPs—should be available for propositional anaphoric reference; many, however, are not. There are a number of both raising and control verbs which do allow for anaphoric reference to the propo-

sitions associated with their embedded clauses, but also a number of both raising and control verbs which do not. That neither the raising verbs nor the control verbs behave uniformly as distinct classes is a significant challenge to any attempt to make a generalization about what introduces propositional discourse referents along syntactic lines: we cannot explain the introduction of propositional discourse referents simply by making reference to a syntactic category, nor to a particular type of movement or extraction. Syntactic category alone is not sufficient, because while some raising/control structures are thought to include CP and others only TP, the split we have observed does not fall along those same lines. And we observed nonuniform behavior even within single classes of verbs (like object raising/ECM verbs), where those classes are defined by their structural composition and the movement which derives them, so that level of syntactic description is inadequate to capture the anaphoric data we're interested in here. Let us explore this difficulty about raising and control verbs, which will motivate the proposal we will advance here, before returning to the list of data which constitute counterexamples to the Krifka 2013 proposal.

There are some verbs which can act as either raising or control verbs, depending on their context. For example, both *promise* and *threaten* are normally control verbs, but they can also be found with expletive subjects when used non-volitionally (Davies & Dubinsky 2004).

(342) a. There promises to be trouble at the concert.

b. It promises to be a beautiful day. (Davies & Dubinsky 2004: (33))

(343) a. There threatens to be a revolution in San Marino.

b. It threatens to be a hard winter. (Davies & Dubinsky 2004: (34))

And this flexibility means that we can see a single verb in constructions that both do and do not license propositional anaphora. Consider *promise* used in its normal volitional

sense, as in (344), and in its non-volitional sense akin to (342), in (345). (I use my own examples, rather than those of Davies & Dubinsky 2004, to control for the eventive/stative distinction.)

(344) Nancy promises to be at the party. (She wants to support me.) RAISING

(345) Nancy promises to be a great violinist one day. (She has the talent.) CONTROL

(344) is a report about Nancy's commitment, and (345) is an assertion of the speaker's estimation of Nancy's future. And these two uses of *promise* have different anaphoric effects:

(346) # Nancy promises to be at the party, but Doug doubts *that*. (He thinks she'll stay at home.) CONTROL

(347) Nancy promises to be a great violinist one day, but Doug doubts *that*. (He thinks she doesn't have the nerve for it.) CONTROL

The follow-ups in both (346) and (347) bias the interpretation of their respective embedded clause propositions as the antecedent of *that*. In (346), this renders the sentence infelicitous: there is no discourse referent available for the proposition associated with the embedded clause. (Doubting the existence of the promise is also bizarre without further context, but that reading is incompatible with the follow-up anyways.) In the felicitious (347), Doug simply disagrees with the speaker about the truth of the embedded clause proposition, 'Nancy will be a great violinist one day'. The embedded clause of (347) does have an associated propositional discourse referent.

The different uses of a verb like *promise* has been argued to be due to lexical ambiguity between a raising and control version of the verb (Perlmutter 1970). It is worth noting, though, that the same is not the case for all control verbs which allow for felicitous anaphoric reference to their embedded clause propositions.

(348) The shit promises to hit the fan. RAISING

(349) * The shit claims to hit the fan. CONTROL

We cannot defend the hypothesis that the distinction between those verbs which allow for propositional anaphora and those that do not is along the lines of raising vs. control.

The argument that *promise* is lexically ambiguous between raising and control variants, then, is not enough to explain the anaphoric effect of this switch, as there is no simple raising/control split which explains the availability of a propositional discourse referent. If all raising verbs made a propositional discourse referent available for their embedded clause, and no control verbs did, then lexical ambiguity would be a sufficient explanation. As it is, though, we have evidence of raising verbs which do not allow for felicitous anaphoric reference to an embedded clause proposition, as in (240), as well as evidence of control verbs which do allow for such felicitous propositional anaphoric reference, as in (244).

Instead, to explain this differing behavior, we must make use of the semantic distinction between the two uses of *promise* above. The volitional/control use in (344) describes an action (even if a stative one) that Nancy intends to take, where the non-volitional/raising use in (345) describes a proposition that the speaker expects will obtain. The important difference here is not one of raising or control, but of the argument type that *promise* takes. One sense of *promise* describes (and so, takes as its argument) an event, and the other describes (and so takes) a proposition. The one that composes with a proposition introduces a discourse referent for it, and the one that composes with an event has no proposition to be introducing a discourse referent for. (Such a proposition can be *composed* for it, using the event and the controlling subject, but that isn't the same as having an already-complete proposition fed as its argument.) This is still an explanation by means of ambiguity, but not simply along the lines of raising vs. control.

The important difference between these two uses of *promise* is not whether they require a raising structure as opposed to a control structure, but whether they combine with an event-denoting complement or a proposition-denoting complement.

This is the generalization that the data illustrated in this chapter suggest: **only operators which take propositions as arguments introduce discourse referents for those propositions**. When I say "operators", this includes not only negation and modals, but also verbs (like *expect*), adjectives (like *likely*), and sentential mood.[58] Most such operators are unary, like the examples listed above, but binary operators like conjunction, disjunction, and implication are also included under this generalization. Paying attention to the semantic type of the argument allows us to distinguish between, for instance, sentential moods which do and do not introduce propositional discourse referents. The declarative mood operator takes a proposition as its argument, as does the matrix polar interrogative mood operator, and so each introduce a discourse referent for its argument proposition. But the imperative mood and *wh-* and alternative interrogative mood operators do not take propositional arguments; they instead take properties as arguments, and so do not have an associated propositional argument to introduce a discourse referent for. This generalization also captures the behavior of modal auxiliary verbs: epistemic modal auxiliaries encode an operator which operates on propositions, and so they have an associated propositional discourse referent; meanwhile root modal auxiliaries do not take propositional arguments, but instead relate individuals and properties (Brennan 1993), and so do not have a propositional argument and thus do not introduce a propositional discourse referent.

This proposal differs from that of Krifka 2013 in two important ways. First, this generalization relies not on syntactic category, but on semantic type. The Krifka 2013 proposal locates the introduction of propositional discourse referents in the Tense Phrase, TP be-

[58] Using the term operator in this way is not novel; see for example Yalcin 2007.

ing a syntactic category, where here what I propose makes reference the semantic type: whether a clause denotes a proposition (as opposed to an individual or property, for example). This generalization is still syntactic in that it is sensitive to combinatorics—which things combine with which things—but it requires a level of description beyond the sorts of categorizations which are typical in the syntactic literature: syntactic category, and movement/extraction type. As discussed above with raising and control verbs, neither syntactic category nor movement type are sufficient to explain the data observed in this chapter. The data presented here might be taken as a reason to reevaluate current syntactic theories[59] or to press for more fine-grained syntactic descriptions which could account for these data. Ultimately, if we want our syntax and semantics to operate hand-in-hand, we might hope for such a fine-grained syntactic description. As things stand, however, the standard tools of modern syntax do not provide the means to describe the pattern we have observed here. Instead, we must make reference to semantic types, to the combinatorics of operators and their arguments.

Second, though, this proposal differs from that of Krifka 2013 in terms of what is doing the introducing. On Krifka's (2013) account, a TP introduces a discourse referent for itself, NegP introduces a discourse referent for itself, and so forth. On the account being advanced here, an operator introduces a discourse referent for the proposition it takes as an argument. In a declarative sentence, the declarative mood operator introduces the discourse referent for the matrix clause (see Bittner 2009, 2011). If a sentence includes sentential negation, the negation operator introduces a discourse referent for its prejacent, and similarly for modals. This allows us to locate the different behavior in (the operator encoded in) a particular small clause embedding verb, for instance, as opposed to attributing the (non-)introduction of a discourse referent to the small clause itself. This

[59]For just one example, the data observed here might be used to argue that epistemic small clauses are covert infinitives, unlike other small clauses; see discussion of (154) and (155). The data here might also be brought to bear when considering analyses of adverbials, modals, raising/control verbs, sentential adverbs, interrogatives, and more.

is necessary, as a single small clause might or might not have an associated propositional discourse referent depending on the verb which embeds it, as we saw in (152) & (153). It is also necessary to explain why a matrix polar interrogative introduces a propositional discourse referent for the partitioning proposition (as in (202)) while an embedded polar interrogative does not (as in 321). On Krifka's (2013) account, if a particular structure (say, a small clause or a polar interrogative) introduces a propositional discourse referent in one context, then it should in every context; the introduction of discourse referents in Krifka 2013 is not sensitive to context. The current proposal can make more fine-grained distinctions by noting the different operators which embed structures (and by paying attention to the semantic types denoted by those structures).

Let us now return to the data presented in this chapter which present a challenge to Krifka 2013, to see how the current approach can handle it. The Krifka 2013 proposal predicts that *tough* constructions, which embed CP complements, should allow for felicitous propositional anaphora to those complements; we observed above that they in fact do not allow for such felicitous anaphoric reference. We can explain this on the current account by noting that the entities that *tough* operates over are an individual and a property (e.g., Dustin and reading *Moby Dick*), not propositions. With no proposition as an argument, no propositional discourse referent is introduced on this account (even if the complement is syntactically a CP).

The proposal in Krifka 2013 asserts that sentential alternative questions like (219) and (221) make discourse referents available for the propositions denoted by each alternative; we observed that this is not the case. On the current approach, we can explain this behavior as a result of the semantic types of these alternatives. Abstracting away from intonation for the moment, neither *Would you like coffee* or *you like coffee* denote propositions, so an alternative question operator would not introduce a propositional discourse referent.

The proposal in Krifka 2013 also predicts that embedded polar interrogatives, like their matrix cousins, should allow for anaphoric reference to the proposition which partitions the answer space. As illustrated in (321), this is not the case: the partitioning proposition of an embedded polar interrogative is not available for anaphoric reference. We can explain this behavior on the current proposal as a difference between the matrix polar interrogative mood as compared to the polar interrogative embedders *whether* and *if*. This explains the presence of "only" in our generalization: *whether* does take a propositional argument (to return a set of propositions), but it doesn't introduce a discourse referent for that proposition.

In summary, the data presented here suggest that the explanation of what introduces propositional discourse referents must be semantic, not purely syntactic. A purely syntactic explanation does not have the tools to distinguish among different small clause embedding verbs, or different control verbs, to the extent required by the facts surrounding propositional anaphora. Even noticing the epistemic nature of the verbs and adjectives which give rise to propositional discourse referents, against the background of a theory which places epistemic modals higher than TP (and root modals below TP), is not sufficient to explain the behavior observed here. A syntactic along the lines of Krifka 2013 account would require all adverbs, adjectives, and even verbs with epistemic modal flavor to raise above TP. And, on top of that, further work would be required to suppress the introduction of propositional discourse referents in *tough* constructions and embedded polar interrogatives. Instead, I propose a semantic generalization, one which locates the introduction of propositional discourse referents not in the syntactic structures which denote propositions, but in the semantic operators which take propositions as arguments. The syntax of a structure influences the semantic composition of its parts, so we cannot ignore the syntactic structure of a construction. And, indeed, the syntax can help to explain certain behavior: if the main clause of a slifting construction is the slifted clause, with the slifting parenthetical in an adjunct (as in Grimshaw 2011), then that would allow

our current generalization to apply to these constructions as well. So, syntactic analysis is a part of the story, but syntax alone does not explain the data observed here.

This generalization about the behavior of propositional discourse referents is not a perfect parallel to Karttunen's (1969) about individual discourse referents. Karttunen 1969 posits that individual discourse referents are introduced for noun phrases within a given sentence, so long as "the proposition represented by the sentence is asserted, implied or presupposed by the speaker to be true" (13). Discourse referents for propositions, as we have seen, are not subject to this restriction. Propositional discourse referents are introduced for the complement of non-factive verbs (as in (269)), which a speaker may, but needn't endorse; for the prejacent of an epistemic modal (as in (181)), which is not a commitment of the speaker; and even for the prejacent of sentential negation (as in (172)), the truth of which the speaker explicitly denies. The introduction of propositional discourse referents is sensitive neither to the truth of a proposition nor to the speaker's attitude towards it.

And, just for completeness's sake, this difference in sensitivity is not due to the difference in containment or 'height' between an individual mentioned within a proposition and the proposition itself. That is to say, where the introduction of an discourse referent for an individual mentioned in a proposition requires that proposition to be "asserted, implied or presupposed by the speaker to be true" (Karttunen 1969: 13), the introduction of a discourse referent for a *proposition* mentioned within a proposition does *not* require that containing proposition to be similarly considered-as-if-true.

(350) It's not true that Jonathan said Nancy was at the party. Steve said *that*. (But he's wrong. She stayed at home.)

We did not explore multiply-embedded cases above, but here we can see that the behavior observed above extends to those cases as well. In (350), the anaphor *that* refers to the

prejacent of the non-factive *said*, even though the *said*-proposition is itself the prejacent of sentential negation. In contrast to the observed behavior of individual discourse referents, the proposition 'Nancy was at the party' gets a discourse referent even though the proposition containing it is asserted to be false in this discourse. (And, with the parenthetical follow-up, we can see that it too can be considered false in the context, but still be picked up felicitously by the anaphor *that*.)

This is a genuine difference between individual and propositional anaphora: individual anaphora requires an antecedent which is (introduced within a proposition which is taken to be) true, but propositional anaphora does not require the antecedent be (considered as if) true. This may be due to a difference between the respective domains of individuals and propositions. The domain of individuals in a discourse is limited to the individuals we consider to 'exist'. This includes fictional individuals (e.g., Sherlock Holmes) and abstract concepts (e.g., the love of one's country), but excludes individuals we know not to exist even in that sense (e.g., the only child's sister). We can always expand the domain of individuals in a discourse by naming a new individual, including a new fictional one (e.g., the sister that the only child might have had), but the domain itself does not include all possible individuals. Propositions, on the other hand, are sets of possible worlds, where the universe of possible worlds includes all possible worlds. The common ground contains those propositions which are considered true in a discourse, and the context set contains those worlds which share the truths known about the actual world (Stalnaker 1974, 1978), but the universe of possible worlds does not shrink to only those worlds, rather it continues to include all possible worlds, even those already ruled out from the context set. Propositions—sets of worlds—include worlds that are already excluded from the context set.[60] There is a sense, then, in which propositions include

[60]Some theories relativize assertion to the existing common ground, making asserted propositions subsets of the common ground (e.g., AnderBois, Brasoveanu & Henderson 2010), but there are reasons to prefer that newly asserted propositions not be restricted in this way (see Murray 2014 on evidentials and Snider 2015 on tautologies).

things that don't 'exist' (worlds that are known to be non-actual), while the domain of individuals only includes those that 'exist'. Or, put another way, there is a sense in which all propositions 'exist'—in that we can continue to make sets of worlds, even if those worlds are known to be non-actual, as the universe of possible worlds is unchanged and exhaustive—where not all individuals do. We track lists of individuals and propositions that have been mentioned in a discourse, and so are available for anaphoric reference, separately from their respective domains. But the nature of their domains might explain why it is that only individuals mentioned in 'true' contexts get discourse referents, while propositions are not subject to this restriction.

While 'truth' is one difference, the data discussed here also point to a similarity between individual and propositional anaphora: discourse referents are introduced only for those entities which are represented formally by a sentence. (For propositional anaphora, this means in the semantics, with a proposition taken as an argument of some operator.) In the individual domain, this has been called the Formal Link Condition (Postal 1969; Kadmon 1987; Heim 1990, a.o.), which requires that a pronoun have an overt NP antecedent, and that this antecedent cannot be a sub-part of a word. This condition explains the infelicity of anaphoric reference to individuals which are salient (but unmentioned) in a discourse (as in (351b)), as well as to individuals whose existence is entailed but who are not named explicitly (as in (352b) and (353b)).

(351) a. One of the ten balls is missing from the bag.
It's under the couch.

b. # Nine of the ten balls are in the bag.
It's under the couch. (Partee 1989)

(352) a. Fritz owns a dog and it bites him.

b. # Fritz is a dog-owner and it bites him. (cf. Evans 1977)

(353) a. Followers of McCarthy are now puzzled by his intentions.

b. # McCarthyites are now puzzled by his intentions. (Postal 1969)

The formal link condition has been argued to be gradient, not categorical, for individual anaphora in English, as sentences which 'violate' this condition are not judged to be uniformly bad (Anderson 1971; Patel-Grosz & Grosz 2010 a.o.). (Patel-Grosz & Grosz 2010 argues that German strong pronouns do observe a strict formal link condition, however.)

Propositional anaphora, similarly, requires a linguistic antecedent to be formally represented in the semantics. We have already observed that a proposition's being conveyed by a sentence is not sufficient for it to have an associated discourse referent: the relationship presupposed by a possessive is not available for propositional anaphoric reference (as in (133)), nor is the existence presupposition of a *wh-* question (as in (209)). And we observed that the complement of the proposition which partitions a polar question is not available for anaphoric reference, even though it is a possible answer to the question—we can perhaps consider this to parallel Partee's (351), in that complementation is not sufficient to make a discourse referent available.

And, as in the individual domain, sentences which violate this restriction on propostional anaphora seem to exist on a gradient scale, not a categorical one. Consider the sentences in (354), all of which convey the proposition 'Jonathan is Nancy's secret admirer' as new information, and as a commitment of the speaker.

(354) a. Jonathan, who is Nancy's secret admirer, told her *that* at lunch today.

b. ? Jonathan, Nancy's secret admirer, told her *that* at lunch today.

c. ?? Nancy's secret admirer Jonathan told her *that* at lunch today.

The only difference among the sentences in (354) is how this proposition is conveyed: in (354a), it is denoted by a relative clause appositive; in (354b), it is conveyed by a nominal

appositive; and in (354c), it is conveyed by a prenominal adjective. Of these, only the relative clause appositive in (354a) denotes a proposition, and thus conforms to the generalization proposed here. Both the nominal appositive and the adjective denote properties, and as such do not conform to our generalization. And, indeed, many speakers find (354b) and (354c) degraded when compared to (354a), but on a gradient scale. Some speakers report a binary distinction between (354a) and (354b,c), others a binary distinction between (354a,b) and (354c), and yet others the full three-way distinction. See Syrett & Koev 2015 for experimental evidence on anaphoric reference to nominal and clausal appositives.

And, to confuse matters further, some speakers report a difference between the triplet in (354) and that of (355), while others report no difference. (I mark the same gradient of acceptability with '?'s, but leave comparison between the triplets to the reader.)

(355) a. Jonathan, who is Nancy's secret admirer, had lunch with her without admitting *that* to her.

b. ? Jonathan, Nancy's secret admirer, had lunch with her without admitting *that* to her.

c. ?? Nancy's secret admirer Jonathan had lunch with her without admitting *that* to her.

In (355), each sentence now has an additional proposition, 'Jonathan had lunch with Nancy', which competes as a potential antecedent. The subordinate clause which contains the anaphor *that* biases interpretation away from this competing proposition—it is odd for Nancy not to know who she had lunch with—but it remains as a competitor nonetheless. For some speakers, this competing proposition is the only available antecedent for the (c) (and possible (b)) variant(s), as the admirer proposition is wholly unavailable, which

renders the sentence bizarre. [61]

Both propositional and individual anaphora, then, share a preference for an antecedent which is overtly represented in the prior discourse. In discussions of the formal link condition on individual anaphora, this representation is syntactic; for propositional anaphora, as discussed here, the representation that matters is semantic, not syntactic. And, in both cases, this preference appears to be just that, a preference, as sentences which do not have this sort of antecedent vary in markedness, which may vary by construction and by speaker.

There is one other interesting point in the data described above which merits further discussion, namely the behavior of *only* and *even*. Considering how similarly *only* and *even* are thought to behave, it is perhaps surprising that they have different patterns of anaphoric availability. As demonstrated in §3.4.8, the prejacent proposition of *only* is not available for anaphoric reference, but the prejacent proposition of *even* is available. And the exclusive proposition of an *only* sentence is available for anaphoric reference, while the scalar proposition of an *even* sentence is not—even though we would associate both of these propositions with the matrix clause of each type of sentence. This presents a puzzle of sorts: why should these similar sentence adverbs behave differently?

[61] Or, consider this alternative example:

(xii) a. Doug McMillon, who is the CEO of Walmart, shopped at the store on Wednesday without telling the cashier *that*.

b. ? Doug McMillon, the CEO of Walmart, shopped at the store on Wednesday without telling the cashier *that*.

c. ?? Walmart CEO Doug McMillon shopped at the store on Wednesday without telling the cashier *that*.

This one, too has the matrix proposition competing but contextually dispreferred, as the cashier would presumably know he shopped there, but might not know he was the CEO.

And, one final alternative example:

(xiii) a. Kevin Jones, who is an Olympic gold medalist, wrote *that* on his OK Cupid profile, but nobody believes *it*.

b. ? Kevin Jones, an Olympic gold medalist, wrote *that* on his OK Cupid profile, but nobody believes *it*.

c. ?? Olympic gold medalist Kevin Jones wrote *that* on his OK Cupid profile, but nobody believes *it*.

Given our analysis thus far, the discourse referent for the matrix clause proposition is introduced by the declarative mood. For the scalar proposition of *even*, which is arguably the main point of a sentence with *even*, to not have an associated discourse referent means it must somehow be beyond the reach of the declarative mood. Structurally speaking, this is clearly not the case: we wouldn't want to analyze *even* as taking wider scope than the declarative mood operator. Instead, we might consider the scalar proposition of *even* not to *outscope* the declarative operator, but to *escape* its scope. If the scalar meaning contributed by *even* is *use conditional* (in the sense of Gutzmann 2013, 2015), as opposed to truth conditional, then that would explain why it escapes the discourse referent introducing scope of the declarative operator.

This proposal is perhaps surprising, but it is not absurd. It would capture the intuition of Karttunen & Peters (1979) that the scalar meaning is secondary to the prejacent, as well as the intuition of Herburger (2016) (which she later discards) that the scalar meaning is not truth conditional. Potts 2007 describes expressive meaning as non-propositional, but Gutzmann 2013, 2015 describes for instance German modal particles and Japanese question particles, which modify propositional content, as expressive (= use conditional). And the scalar meaning contributed by *even*, though it has been discussed in the literature as a proposition, is doing just that: modifying a proposition. It takes the prejacent proposition and conveys the speaker's attitude toward it, namely one of surprise. Like other expressive content, the scalar meaning of *even* when embedded in a report can describe either the speaker's attitude or the matrix subject's, as in (356).

(356) Barb said even Steve might pass the exam.

OK: Barb thinks Steve was unlikely to pass.

OK: Speaker thinks Steve was unlikely to pass.

And, like other expressive content, the scalar meaning of *even* cannot be targeted by negation, as we can see in (357).

(357) Not even Nancy could pass this exam.

= Even Nancy could not pass this exam.

= Nancy could not pass this exam (which is surprising)

$\neq$ Nancy is not among those least likely to pass this exam.

And, like other expressive content, it doesn't form part of the content of a question.

(358) Did even Nancy pass the exam?

a. Yes, but she's one of the smartest in the class, so it wasn't surprising.

b. # No, but she did pass.

Gutzmann 2013 also lists direct dissent as a test for use conditional meaning, but that makes use of response particles like *no* which are themselves anaphoric (Krifka 2013; Roelofsen & Farkas 2015), and we have already observed that the scalar meaning of *even* is not available for anaphoric reference. (This same point may render the question-answering test similarly redundant, depending on how anaphoric one's theory of question-answer congruence is.)

Only does not show the same behavior for these various tests. So we have reason, perhaps, to consider the scalar meaning of *even* as inherently different from the exhaustive meaning of *only*: the former is use conditional, the latter truth conditional. This, in turn, has consequences for their anaphoric availability. And, under the analysis being developed here, these facts are not coincidental. A propositional discourse referent is introduced for a proposition by an operator that takes it as an argument; here, we're focusing in particular on the declarative mood operator. The exhaustive meaning contribution of *only* is truth conditional, and so is taken as an argument by the declarative mood operator, and so it gets an associated discourse referent. The scalar meaning contribution of *even*, however, is use conditional, and use conditional meanings are not computed in

the same way as truth conditional meanings. They escape targeting by operators, as we saw with negation above. So the scalar meaning of *even* is not taken as an argument of the declarative mood operator, and thus has no associated propositional discourse referent.

The present analysis, then, can neatly account for this asymmetry between *only* and *even*. No extra operators or movements are required, and no discourse referents are 'erased'. Rather, if we take the use conditional nature of the scalar meaning of *even* into account, this behavior falls out naturally from our theory.

Only, meanwhile, makes a discourse referent available for the matrix clause, and not for the prejacent proposition. Under the current proposal, the only way for this to obtain is for *only* to take something other than a proposition as its argument: the discourse referent for the exclusive implication is introduced by the declarative mood operator, and *only* must contribute this meaning (outputting a proposition) without taking a proposition as its argument. This would require us to insist on a modification to chapter 3 of Rooth 1985, which moves from an analysis wherein *only* takes an individual and a property to one where the basic meaning of *only* takes a proposition as its argument. A move (back) towards *only* composing first with an individual has been suggested more recently, however (Zimmermann 2017). While it is indeed standard in the literature for *only* to take a propositional argument (e.g., see Coppock & Beaver 2013 and discussion therein), it has been suggested that understanding *only* as quantifying over propositions cannot in all cases capture the same desired meanings as quantification over individuals (Zimmermann 2017). The propositional anaphora data presented here may be yet another push in this direction, though it would require reevaluation of a good deal of the current literature on *only*.

CHAPTER 4

MODELING PROPOSITIONAL ANAPHORA

4.1 Introduction

In the previous chapter, we examined a variety of constructions to see when propositional discourse referents are introduced. We observed that propositional discourse referents are introduced for subclausal constructions (including epistemic small clauses and epistemic adverbials), for monoclausal constructions (including matrix declaratives, and the prejacents of sentential negation and of epistemic modals), for multiclausal constructions (including some raising and control constructions, embedded finite clauses, and relative clauses), and for multisentential constructions (like conjunction and disjunction). Ultimately, the generalization was that operators which take propositional arguments introduce discourse referents for those arguments.

In this chapter, we explore how to formally model this behavior. Modeling a phenomenon formally requires us to be precise about the mechanisms that drive its behavior and the assumptions that underlie our work. Formal models also make concrete predictions which can then be confirmed or falsified, advancing our understanding of the topic at hand. Propositional anaphora is no different: a formal model will help clarify our understanding of how propositional anaphora works.

First, I introduce the landscape of formal systems in the literature which might bear on this project. §4.2 reviews existing formalisms that model anaphora, and §4.3 reviews existing formalisms which use propositional variables. For each formal system, I briefly discuss what changes to the system (if any) would be necessary for it to be able to handle propositional anaphora and the behavior observed in Chapter 3. In §4.4, taking inspiration from the various systems discussed, I sketch out a new formalism to model the

generalization proposed in the previous chapter.

4.2 Background on modeling anaphora

In this section, we'll look at some of the ways in which anaphora has been modeled formally. In particular, we will consider Dynamic Predicate Logic (Groenendijk & Stokhof 1991, §4.2.1), Discourse Representation Theory (Asher 1993, §4.2.2), two dynamic modal predicate logics (van Eijck & Cepparello 1994, §4.2.4; Groenendijk et al. 1995b, 1996, §4.2.5), Predicate Logic with Anaphora (Dekker 1994, §4.2.3), and Update with Centering (Bittner 2009, §4.2.6).

4.2.1 Dynamic Predicate Logic (Groenendijk & Stokhof 1991)

In a standard static first-order predicate logic (PL), anaphors are variables. Sentences are interpreted with respect to both a model, which contains the entities and predicates relevant for interpretation, and an *assignment function*, which assigns variables to entities. For example, a sentence like (359a) is interpreted as in (359b), relative to a model $\mathcal{M}$ and an assignment function g.

(359) a. She napped.

b. $[\![\text{napped}(x)]\!]^{\mathcal{M},g}$

This sentence will be true if and only if the individual that g maps to x did in fact nap in the model. Given a model, then, we can consider a sentence to denote the set of assignment functions that verify it.

Dynamic Predicate Logic (DPL; Groenendijk & Stokhof 1991) was created to account for cross-sentential anaphora and donkey-sentences, and—as anaphors are considered to be (syntactically free) variables—the binding of variables. In DPL, a sentence denotes not

a set of assignment functions but a *relation* between sets of assignment functions, represented as a set of ordered pairs of assignment functions: input/output pairs of assignment functions. In this system, formulas with the existential quantifier $\exists x$ change the variable assignment for x in the output: they change the assignment function in terms fo what it assigns x to. Formulas without the existential quantifier, including atomic formulas, are tests on input/output pairs: they don't change variable assignment in any way, but they ensure that the assignment pair verifies the formula (just as in static PL). One other key change in DPL is that the variable binding of $\exists x$ can continue indefinitely rightward, including across sentence boundaries, unless it is closed by a closure operator. Thus, the sentences in (360a) and (361a) are translated into DPL as in (360b) and (361b), respectively, and the discourse in (362a) is translated into DPL as in (362b).

(360) a. A man walks in the park.
b. $\exists x[\text{man}(x) \wedge \text{walk\_in\_the\_park}(x)]$

(361) a. He whistles.
b. $\text{whistle}(x)$

(362) a. A man walks in the park. He whistles.
b. $\exists x[\text{man}(x) \wedge \text{walk\_in\_the\_park}(x)] \wedge \text{whistle}(x)$ (Groenendijk & Stokhof 1991)

Even though the final x in (362b) is not contained within the brackets, it is still dynamically bound by the existential quantifier, so we interpret *he* as referring to the man walking in the park. DPL is thus compositional at the sentence level: the same DPL translation is assigned to *He whistles* regardless of any prior discourse context. It is the dynamic binding of DPL that allows the pronoun to be interpreted in a way that is sensitive to context. A fragment of DPL is presented in the Appendix in Figure 2.

In DPL, the meaning of a sentence is not just its truth conditions, but also its dynamic potential: its (in)ability to bind variables in subsequent discourse.[62] Truth conditions are "an essential ingredient of meaning", but "truth conditions do not exhaust meaning" (Groenendijk & Stokhof 1991: 98). Even though the first sentences in (351a) and (351b)

[62] And presumably, to account for cataphoric pronouns, in preceding discourse as well.

(repeated here) are truth-conditionally equivalent, they have different anaphoric effects: only (351a) allows for felicitous follow-up using the anaphor *it*.

(351) a. One of the ten balls is missing from the bag. It's under the couch.

b. # Nine of the ten balls are in the bag. It's under the couch. (Partee 1989)

On a DPL account, only (351a) can 'capture' the variable denoted by *it* because (351a)—but not (351b)—contains an existential quantifier. (351b) are truth conditionally equivalent, but their dynamic potential is different. Groenendijk & Stokhof 1991 introduces the notion of a satisfaction set, which reduces a DPL interpretation to a PL interpretation—that is to say, that looks only at the truth conditions of a DPL formula, but ignores its dynamic potential.

DPL as designed handles individual anaphora, but not propositional anaphora: Groenendijk & Stokhof 1991 mentions neither propositions nor possible worlds. In order to account for propositional anaphora within DPL, we would have to extend the vocabulary of DPL to include propositional variables, and to allow for quantification over these propositional variables. It will be the existential quantifier, in particular, which introduces propositional discourse referents, in that it will allow for the dynamic binding of the propositional variables denoted by anaphors like *that*. And, as what goes up must come down, we will need the existential closure operator to work for propositional quantification as well. This closure operator is necessary to model the behavior of propositions which are available for anaphoric reference within one domain but not beyond it—or, in Groenendijk & Stokhof 1991 terms, for structures which are internally dynamic (and allow for variable binding) but externally static (and thus do not permit subsequent anaphoric reference). For example, as we observed in §3.4.5, restrictive relative clauses introduce propositions which are available for anaphoric reference from within the clause containing the relative clause, but are not available from subsequent clauses. In a propositional

extension to DPL, we would need a propositional existential closure operator to capture this fact.

On this note, it is not obvious that the other logical operators ($\wedge, \vee, \rightarrow$) will have the same dynamic properties for propositional variable binding as they do for individual variables, as laid out in Groenendijk & Stokhof 1991. For example, concerning individual anaphora, Groenendijk & Stokhof 1991 describes three versions of disjunction: in section 2.5, one which is both internally and externally static; in section 4.3, one ("program disjunction") which is internally static but externally dynamic;[63] and in section 5.1, one which is both internally and externally dynamic. Groenendijk & Stokhof 1991 ultimately leaves the question open, but notes that the first two can be derived from the third via the closure operator. For propositional anaphora, however, the data observed in §3.5.2 suggest that disjunction must be internally dynamic but, at least for the left disjunct, externally static. Anaphoric reference to the proposition denoted by the left disjunct is felicitous for an anaphor in the right disjunct—internally dynamic—but infelicitous for an anaphor in a subsequent clause—externally static.[64] A propositional DPL, then, cannot simply transpose the logical operators of standard DPL, expecting that the dynamic behavior of propositions is the same as that of individuals.

Additionally, a propositional DPL would need some method for associating a propositional variable with its character, that is, with the formula which denotes it. For instance, on the assumption that the sentence in (360a) denotes a proposition, and considering that we may want to model reference to that proposition, we would need to associate a propositional variable (say, p) with the content of (360b). This might be done with an altered version of $=$ (which would also be needed to be added to the system), though then ques-

[63] That is to say, an individual variable in one disjunct cannot be bound by the other, but an existential quantifier in either disjunct can bind a variable in a subsequent sentence.

[64] Anaphoric reference from a subsequent clause is still felicitous to the disjunction as a whole, but this is a feature of the sentence as a whole (e.g., of the declarative mood, as discussed in the previous chapter), not of disjunction. We are talking here about the dynamic properties that disjunction imparts for its arguments, i.e., the disjuncts.

tions arise about both the semantic type of a proposition, as well as whether the character of a proposition can or should include the dynamic potential of a sentence (i.e., the $\exists x[\ldots]$ frame).

We will return to some of these issues in §4.4.

4.2.2 Discourse Representation Theory (Asher 1993)

Asher 1993 explores anaphoric reference to abstract entities (including events, concepts, facts, and propositions) in Discourse Representation Theory (DRT; Kamp 1981) and an extension thereof, Segmented Discourse Representation Theory (SDRT). In DRT, sentences are translated into discourse representation structures (DRSs), which consist of a universe of discourse referents and a set of conditions. These are frequently presented in boxes, as in (363b), with the list of discourse referents on the top line of the box, and the conditions listed below.

(363) a. A boy kicked Fred. (Asher 1993: 66, (1))

b.

x, y
boy(x)
Fred(y)
kick(x,y)

(Asher 1993: 66, (K1))

Sequences of sentences are combined via DRS-merge, which unions both the universes and conditions of the DRSs it combines, as in (364), which also illustrates how anaphora is handled in DRT. In DRT, anaphors are translated as variables awaiting assignment, that assignment proceeding after DRS construction, via anaphora resolution.

(364) a. A boy kicked Fred. He cried. (Asher 1993: 67, (3))

b.

x, y, z
boy(x)
Fred(y)
kick(x,y)
cry(z)
z = ?

(Asher 1993: 67, (K3))

The anaphor *he* in (364a) is translated as the variable z in (364b), which is not yet linked to any antecedent; after anaphora resolution, the DRS for (364a) would be as in (364c).

(364) c.

x, y, z
boy(x)
Fred(y)
kick(x,y)
cry(z)
z = y

(Asher 1993: 68, (K'3))

In DRT, DRSs can be embedded inside one another (making one a subDRS of the other), and translations of quantifiers, conditionals, and certain embedded clauses make use of this feature. For example, the donkey sentence in (365a) is translated into the DRS in (365b) prior to anaphora resolution.

(365) a. If a high school student owns a mustang, he works on it every day.

(Asher 1993: 76, (6))

b.

x, y		z_1, z_2
high-school student(x)	⇒	z_1 = ?
Mustang(y)		z_2 = ?
own(x, y)		work-on-every-day(z_1, z_2)

(Asher 1993: 76, (K6))

The structural configuration of how subDRSs are embedded has consequences for anaphora resolution in DRT, as only certain universes of discourse referents are accessible from one (sub)DRS to another. For instance, discourse referents in the universe of the antecedent of a conditional are available to its consequent—which allows z_1 and z_2 from (365b) to be identified with x and y, respectively—but the discourse referents introduced in a consequent are not accessible from the conditional antecedent. A fragment of DRT is presented in Figure 3.[65]

Asher 1993 introduces propositional variables for DRT when considering examples with attitude predicates like *believe* that take a clausal complement. It is *not* the case, how-

[65]Some of the definitions given have unpaired brackets or other minor typographical peculiarities; these are original in Asher 1993. The condition definitions of the vocabulary of Figure 3 are shortened to reduce redundancy with the definition of terms above, but otherwise this fragment is copied verbatim, including numbering.

ever, that the clausal complement is simply assigned a propositional discourse referent, which the attitude predicate takes as its argument. Instead, the predicate takes a sub-DRS as its argument; a propositional discourse referent is only introduced if a subsequent sentence contains a propositional anaphor. As Asher 1993 explains:

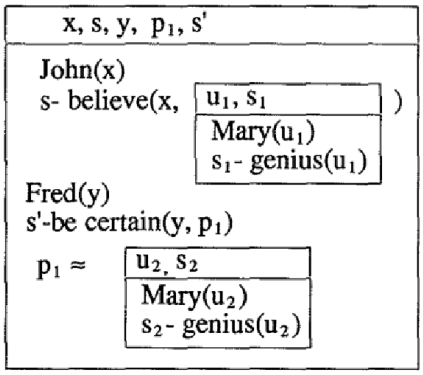
> "[A] *that* clause introduces a DRS, not a discourse referent. Nevertheless, this DRS has an ontological status. It may be anaphorically referred to".
>
> (Asher 1993: 172)
>
> "A noteworthy feature of the partial DRS introduced by the complementizer is that no discourse referents for the propositional argument are introduced. It will turn out that proposition type discourse referents may occupy the same argument position in the translation of an attitude verb as the subDRS contributed by an embedded clause. But there is no need to introduce discourse referents when translating the *that* clause. A subDRS as an argument to a predicate of DRSs is rather like a constant or a complex term if it involves discourse referents that are not declared in its universe; the model theoretic interpretation of predicates of DRSs implies that a subDRS as an argument denotes a designated object in the model. Since a subDRS is not a discourse referent, it is not assigned a value under any embedding function. But by construing them as constants for abstract objects, they denote the same object in the model regardless of the DRS in which they were declared and what embedding function was being considered. We don't need to introduce discourse referents for *that* clauses for semantic reasons. Further, such discourse referents are not needed to account for scope ambiguities or quantificational dependencies; subDRSs do not have any. Finally, subDRSs are already recognizable constituents of DRSs, should we wish to identify discourse referents with them anaphorically. Thus, discourse referents introduced by *that* clauses appear otiose." (Asher 1993: 117)

If a subsequent clause includes an anaphor which refers back to the contents of a complement clause, then a propositional discourse referent is introduced and associated with (an equivalent to) that subDRS, as in (366b).

(366) a. John believes that [Mary is a genius]$_i$. Fred is certain of it$_i$.

(Asher 1993: 241, (23))

b.



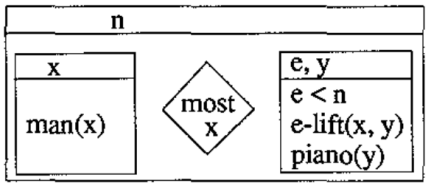
(Asher 1993: 242)

The DRS in (366b) is the output of the DRS-merge of two DRSs, one for each sentence. The first two conditions are associated with the DRS translation of the first sentence, and the remaining three conditions are associated with the second, containing the anaphor. The translation of *John believes that Mary is a genius* alone involves the introduction of discourse referents for two individuals (x and u_1) and for two states (s and s_1) but no propositional discourse referents (let alone the two that we might want, given the previous chapter). As per the quote above, this translation gives us two boxes (one subDRS and one DRS) which can be antecedents of propositional anaphora, so no propositional discourse referents are introduced.

This association of (sub)DRSs with structures that can antecede propositional anaphora is problematic, however. First, there are subDRSs for structures which aren't available for propositional anaphora, such as the restrictor of a quantifier.

(367) a. Most men lifted a piano. (Asher 1993: 92, (15.b))

b.



(Asher 1993: 92)

Following Kamp & Reyle 1993, Asher 1993 translates the sentence in (367a) with the DRS in (367b). This translation contains subDRSs for both the restrictor and the nuclear scope of the quantifier, but we would not want to say that either *men* or *lifted a piano* introduce a

proposition which is available for anaphoric reference. Making all subDRSs available antecedents for anaphoric reference amounts to saying that (367a) makes three propositions available for anaphoric reference.

Second, there are constructions which DRT does not translate with a subDRS but which nevertheless are available for propositional anaphoric reference. For example, relative clauses are translated as predicative DRSs which are immediately (DRS-)merged with the matrix DRS, thus moving the universe and conditions associated with the relative clause into the main 'top-level' DRS. The DRS given in (365b) above for *If a high school student own a Mustang, he works on it every day* (365a) "is equivalent to the one for *every high school student who owns a Mustang works on it every day*" (Asher 1993: 77). As we observed in Chapter 3, relative clauses make propositions available for anaphoric reference; see (282) & (286), repeated here.

(282) Every student who cheated on the test told their mother $\left\{\begin{array}{l} \textit{that} \\ \textit{so} \\ \textit{as much} \end{array}\right\}$.

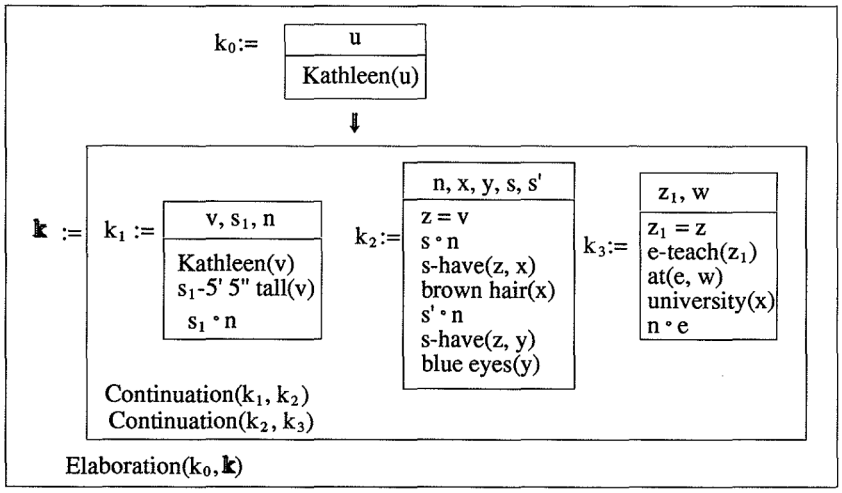
(286) Steve, who cheated on the test, got an 100. But Nancy doesn't know *that*, she thinks he's just really smart.

In DRT, however, relative clauses are not associated with either a propositional discourse referent or a subDRS, and so cannot antecede propositional anaphors. DRT as presented in Asher 1993 cannot account for the data observed here, then, nor is the one-to-one association of (sub)DRSs with propositional antecedents sufficient—if this association were to be maintained, one would need to recast the DRT treatment of at least quantifiers and relative clauses.

Asher 1993 later introduces an extension of DRT, Segmented DRT, which models the discourse and coherence relations that connect segments of discourse. Each discourse segment (i.e., SDRS) is assigned a variable as a label—(e.g., k_0–k_3, $\mathbb{k}$ in (368b))— and those

variables are the arguments of relations.[66] These variables are not discourse referents, however: they are not part of the universe of accessible referents in any SDRS.

(368) a. Kathleen is five feet 5 inches tall. She has brown hair and green eyes. She teaches at a university. (Asher 1993: 276, (7))

b. 

(Asher 1993: 278)

SDRT introduces explicit labels for every SDRS, but these are not equivalent to propositional discourse referent variables. Nevertheless, like DRSs, SDRSs themselves are available antecedents for propositional anaphora. Asher 1993 is careful to note that the relationship between a propositional anaphor and its SDRS antecedent is different than the anaphoric relationship for other types:

> "There is a question about the interpretation of proposition anaphora now that we may characterize discourse referents using SDRSs. How are we to interpret the link between a discourse referent introduced by a pronoun and an SDRS? It is inadvisable to interpret that link as identity. For if we do, we may commit ourselves to the view that all discourse structure is integral to the information content of the discourse itself, and that seems wrong." (Asher 1993: 319)
> "Discourse relations serve to determine what are the possible propositional antecedents for the discourse referent but at least sometimes are not constitutive of their content. So we cannot understand anaphoric relations involving SDRSs in just the same way as we do the paradigm cases of individual anaphoric relations. A natural alternative is to take an SDRS to determine

[66]The set of relevant discourse segments includes the understood topic k_0, even though it is not associated with any clause in the discourse.

> a proposition–the proposition that is the sum of its leaves–and to take this proposition as the anaphoric referent." (Asher 1993: 320)

Ultimately, Asher 1993 draws a parallel between anaphoric reference to SDRSs and anaphoric reference to plural individuals, which can be constructed 'on the fly' for singular individuals (as in (369)).

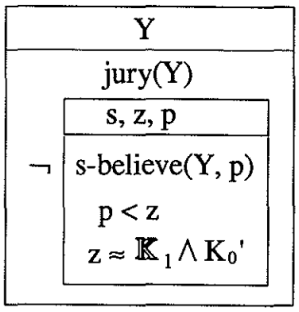
(369) Susan went camping with Bill. They enjoyed it. (Asher 1993: 92, (16))

Treating propositional anaphora similarly allows for anaphoric reference to the understood topic of a discourse which is 'constructed' in a similar way; in other words, it allows for anaphoric reference to the proposition denoted by a whole sequence of connected sentences—the proposition, but not the internal structure of the SDRS.

> "I will interpret an SDRS $\mathbb{K}$ as a group of constituents. My interpretation of an anaphoric link between a discourse referent and an SDRS follows the explanation of plural anaphora in DRT. A condition of the form $\mathbf{z} \approx \mathbb{K}$ is satisfied relative to an embedding function f, world w and time t just in case f($\mathbf{z}$) in w at t is a collection of DRSs, such that there is a bijection g from f($\mathbf{z}$) onto the set of DRS constituents $<_{tc} \mathbb{K}$ and for K $\in$ f($\mathbf{z}$), K and g(K) are alphabetic variants. I do not incorporate the discourse relations or the topic structure into the interpretation of the anaphor. This would yield incorrect results, as I argued earlier." (Asher 1993: 334)

For example, to emphasize the connection to plurality, Asher 1993 models the "distributive" reading of the last sentence of the discourse in (370a), the reading wherein the jury didn't believe any of the plaintiffs, with the DRT translation in (370b).

(370) a. One plaintiff had never received his full pay. Another had been passed over for promotion three times. Yet another had been denied a job because of his race. But the jury didn't believe **it**. (Asher 1993: 330, (13))

b. 

(Asher 1993: 334)

Note that the anaphoric variable z is linked to the complex topic $\mathbb{K}_1 \wedge K'_0$, which represents the sum of the first three sentences of (370a). SDRT thus allows the relevant SDRS structures which compose topics to be antecedents of propositional anaphora, even though the SDRS labels are not part of any universe of discourse referents.

This construction of 'summed' propositional antecedents is important, and a feature we should want in our formal system. And the SDRS in (370b) illustrates another feature of DRT which comports with the data observed in the previous chapter, namely that negation ($\neg$) takes a subDRS as its argument. That, alongside the assumption in DRT that all (sub)DRSs are potential antecedents from propositional anaphora, means that the prejacent of negation should be similarly available, which the data confirms.

There are some other features of (S)DRT, however, which do not comport with the data observed in Chapter 3. Negation takes a subDRS argument, and the same is true for the modal operator $\Box$, not part of the Asher 1993 fragment but nevertheless used (Asher 1993: 83,116,247,250). As we observed in §3.3.1, however, the flavor of a modal has implications for the propositional anaphoric potential of its antecedent: epistemic modals make their prejacents available for propositional anaphora, but root modals do not. For DRT to capture this, either only epistemic modals would be translated as having subDRS arguments (retaining the concept that all (sub)DRSs are potential propositional antecedents), or only epistemic modals would add a propositional discourse referent into the containing DRS's universe (dispensing with that concept). Similarly, DRT translates

all attitude predicates as taking subDRS arguments, even for infinitival and *for*-clause complements (Asher 1993: 181) but as we saw in §3.4.1, the nature of the embedding verb has implications for the availability of its argument for propositional anaphora. To assign all embedding verbs subDRS arguments (just like all modals) is insufficient, as it falsely predicts felicity for many examples of impossible propositional anaphora. And, similarly, Asher 1993: 183 assigns subDRS arguments for nominalized *for*-clauses, which we saw are not available for propositional anaphoric reference (e.g., in (295)).

Adapting (S)DRT to capture the data presented here, then, would require some changes to the system. Perhaps the most minimal change would be to dispense with the assumption that all (sub)DRSs are available antecedents for propositional anaphora and to instead have propositional discourse referents robustly represented in DRS universes. This would require a change to the DRS construction algorithm such that it would introduce explicit propositional discourse referents for the prejacents of negation, epistemic modals, and certain embedding verbs, as well as for relative clauses, and so on. Alternatively, should one want to maintain that assumption, the DRS construction algorithm would have to take into account the nature of an embedding verb, for instance, before assigning a structure to its complement; this strikes me as counter to the intention of DRS construction.

Matrix clauses, meanwhile, would introduce propositional discourse referents into a larger discourse-level universe of discourse referents (akin to where the SDRS labels exist), such that they, too, could be antecedents of propositional anaphors in subsequent discourse units (but not for anaphors they contain). This also suggests an SDRT approach, where discourse units are maintained separately, over a DRT approach in which subsequent clauses are DRS-merged together, so as to keep track of which clauses' propositional discourse referents are accessible to which anaphors. This would also us to maintain the other benefits of the SDRT approach, including the construction of 'summed'

propositions (discussed in Asher 1993), as well as sensitivity to the right frontier (Polanyi 1988, e.g., as formalized in Lascarides & Asher 2008).

4.2.3 Predicate Logic with Anaphora (Dekker 1994, 2012)

Just like DPL, Predicate Logic with Anaphora (PLA; Dekker 1994, 2012) is an extension of PL with compositionality as a primary goal. Unlike DPL, however, PLA is an update semantics, so it involves the tracking (and growth) of information, as formulas update information states. A PLA information state includes information about subjects: "These subjects, composed of the possible values of candidate antecedent terms, are the potential 'referents' of subsequent anaphoric pronouns' (Dekker 1994: 80). Rather than treating anaphors as (syntactically free, semantically bound) variables, as they are in DPL, PLA treats anaphors as syntactic objects which index the list of possible subjects in the current information state. A fragment of PLA is presented in Figure 4.

Under this system, a sentence which introduces a(n individual) discourse referent, as in (371a), is translated as containing an existential quantifier, as in (371b).

(371) a. There is a man.

b. $s \llbracket \exists x Mx \rrbracket_g = \{e \cdot d \mid e \in s \llbracket Mx \rrbracket_g [x/d]\}$

$= \{e \cdot d \mid e \in s \ \& \ d \text{ is a man}\} \ (= s')$ (Dekker 1994: (5))

It is this existential quantifier which adds a new discourse referent to the information state (extending the list of subjects being tracked, $e \cdot d$). This new expanded information state is then constrained, to ensure that the output information state (s') only includes cases in which the most recent subject is a man.

With an information state tracking subjects, PLA has pronouns refer to those subjects by the position in the information state, which tracks the order in which they were in-

troduced. So a pronoun translated as p_0 picks out the most recently introduced subject, p_1 picks out the second most recent subject, and so on. How we translate an object language pronoun into PLA will determine which referent is picked out, depending on the information state against which it is interpreted. If we interpret (372a) as occurring immediately after (371a), and translate *he* as p_0, then we get the translation and interpretation in (372b).

(372) a. (There is a man.) He walks.

b. $s' \left[\!\left[W \mathrm{p}_0 \right]\!\right]_g = \{e' \in s' \mid \text{the last element of } e' \text{ walks}\}$
$= \{e \cdot d \mid e \in s \;\&\; d \text{ is a man } \&\; d \text{ walks}\}\ (= s'')$ (Dekker 1994: (6))

This sentence introduces no new discourse referents—it contains no existential quantifier—but it refers back to the list of existing discourse referents, and constrains the information state by only retaining cases where the most recently introduced subject walks. Though the argument of W in (372b) picks out the same referent as the argument of (371b)'s M, they are not both (bound) variables, as in DPL. The pronoun p_0 happens to pick out the same referent, but isn't itself a variable, and isn't bound.

Dekker 1994 deals only with individual anaphora, and while Dekker 2012: chapter 3 adds intensionality and thus worlds, it still doesn't account for propositional anaphora (nor does it intend to).[67] In order to extend PLA to deal with propositional anaphora, we would need to add a set of propositional variables. We would also need to add a set of propositional anaphors, perhaps denoting the type of an anaphor via subscripts, as in anaphors to individuals $\mathrm{p}_{e,0}$, $\mathrm{p}_{e,1}$... and anaphors to propositions $\mathrm{p}_{p,0}$, $\mathrm{p}_{p,1}$... This implies that we would need to represent propositional discourse referents in the information

[67] Dekker 2012: 85, footnote 3 says that "The issue [of propositional anaphora] has been dealt with by Roberts 1989; Frank 1997; Geurts 1999; Stone & Hardt 1999; Brasoveanu 2006, among many others." These works, though, deal with propositional anaphora only infofar as it is involved in cases of modal subordination. None of them deal with anaphoric reference to propositions in the way that I am interested in here.

state, though we would have a choice between each case in an information state having distinct lists (one for individual discourse referents, one for propositional) or having a single list with typed entries. This latter option would in turn require that the anaphors pick out their referents from that list not rigidly by position, but by position *relative to type*—that is to say, $\mathrm{p}_{p,1}$ would refer to the second most recently introduced proposition, even if that was the fifth most recently introduced discourse referent overall.[68] I won't discuss further the consequences of choosing between a one-list and two-list system.

Also, PLA forbids the existential quantifier from occurring under the scope of negation, to capture the inability of individual discourse referents to be introduced under negation (Dekker 2012: 15). Propositional anaphora, however, behaves differently.

(373) a. # Steve doesn't have a car. *It* is red.

b. Steve doesn't have a car. Nancy believes *that*, though.

A propositional extension of PLA, then would need to either (i) lift this restriction for the propositional existential quantifier, maintaining it for the individual existential; or (ii) ensure that the propositional existential always scopes wider than negation. The proposal advanced in Chapter 3 suggests that sentential negation itself should encode a propositional existential quantifier, as it introduces a discourse referent for its prejacent, but that does not decide between these two options. In DPL, negation is a test, so it nullifies the dynamic potential of any existential operators in its scope, thus no such restriction is needed.

And, finally, as with DPL, a propositional extension to PLA would need to introduce a method for identifying a propositional variable with the proposition it represents. This might be via an adaptation of $=$ which, instead of testing that the referents of two terms

[68] E.g., in a case whose list of discourse referents looked like $\langle \ldots, r_p, x_e, q_p, y_e, z_e \rangle$, the pronoun $\mathrm{p}_{p,1}$ would refer to r, which is the second most recent propositional discourse referent (counting from the right). It wouldn't refer to the second most recent discourse referent overall, y, because y is the wrong type.

are the same, would assign a variable to a formula of PLA. The same question mentioned above, about whether to include the existential quantifiers of a formula within the stored identity of that variable, would apply equally here.

4.2.4 van Eijck & Cepparello 1994

van Eijck & Cepparello 1994) introduces a dynamic modal predicate logic to combine the dynamic variable binding from DPL (Groenendijk & Stokhof 1991) with the epistemic updating from Veltman's (1996) update semantics. The goal of the project is to account for the anaphoric relationship in (374) and the infelicity of the discourse in (375).

(374) A man walked out. Maybe he was angry. (van Eijck & Cepparello 1994: (1))

(375) Maybe he was angry. *A man walked out. (van Eijck & Cepparello 1994: (3))

"Our aim in this paper is to develop a logic that gives an account of the interaction of the processes of anaphoric linking and epistemic updating" (van Eijck & Cepparello 1994: 2). They do this by distinguishing between things which range over possible states of affairs (like *might*) and those which range over variable assignments (like DPL's new variable introducer).[69] Evaluation, then, is relative to both possible states of affairs and an input/output pair of assignments. A fragment of this system is in Figure 5.

In this system, the universe M is the domain of discourse, and W is the set of first order interpretations over M, possible ways M could be—that is to say, W is a set of possible worlds. Index sets, then, being subsets of W, are propositions. van Eijck & Cepparello 1994 models the interpretation of a formula (relative to a pair of assignments) as a function from index sets to index sets—given a proposition, updating with a formula brings you to a new proposition. That index set, then, represents the discourse's current

[69] Groenendijk & Stokhof 1991 uses the existential quantifier $\exists$ for this, as given above; van Eijck & Cepparello 1994 describe this as the random variable assignment $v :=?$. This is a notational difference, not a theoretical one.

worlds under consideration, akin to the Stalnakerian context set.

The introduction of index sets allows van Eijck & Cepparello 1994 to handle epistemic *might* by making reference not just to assignments but to states of affairs. As presented here, however, these index sets do not suffice to account for the propositional anaphora we are interested in. This system keeps track only of the current evaluation index set (i.e., the context set), but does not maintain a list of past index sets that could be considered a list of propositional discourse referents. It also doesn't model index sets for the representations of (sub)formulas which do not actually update the index set, e.g., the prejacents of negation or modals. As we have seen in Chapter 3, an adequate model of propositional anaphora will need to be able to model propositions which are not commitments of the speaker and which therefore do not update the common ground. The introduction of propositions in van Eijck & Cepparello 1994 gets us closer to the sort of system we want, but it alone cannot model the data we are interested in.

4.2.5 Groenendijk, Stokhof & Veltman

Like van Eijck & Cepparello 1994, Groenendijk, Stokhof & Veltman 1995b, 1996 introduce a dynamic modal predicate logic in an effort to combine the dynamic variable binding of DPL with the update semantics of Veltman 1996. The implementation is different, however. Groenendijk et al. 1995b, 1996 have a different definition for the modal operator $\Diamond$ such that it evaluated against both worlds and assignments, and a different definition for the existential quantifier so that, when in combination with $\Diamond$, it results in variable-by-variable assignment rather than global assignment. These two systems end up making different predictions about the consistency of discourses (sequential updates)

like (376).

(376) Someone has done it. It might be you. But it might also not be you.

$\exists!xPx \wedge \Diamond(x = \textit{you}) \wedge \Diamond(x \neq \textit{you})$ (Groenendijk et al. 1995b: (28))

These two changes also end up limiting the ability of existential quantifiers to freely (and equivalently) bind any rightward variables: formulas that include $\Diamond$ change the information state against which subsequent variables are interpreted. This means that, in this system, $\exists Px \wedge \Diamond Qx \not\equiv \exists x(Px \wedge \Diamond Qx)$. A fragment of this system is in Figure 6.

While the system in Groenendijk et al. 1995b, 1996 isn't explicitly restricted to variables for individuals, it inherits from Groenendijk & Stokhof 1991 and Veltman 1996 a focus on individuals (and thus, individual anaphora). Each possibility in an information state is interpreted relative to a possible world, and so has a privileged position for that world. Beyond that evaluation world, though, possibilities don't track sets of other worlds (e.g., as presented in Groenendijk, Stokhof & Veltman 1995a). They might be made to, if propositions were considered to be part of the domain of discourse D in the same way that individuals are. As described in Groenendijk et al. 1995b: fn. 9, though, "propositional variables are zero-place predicates", not true variables. They evaluate to true or false given a world, but cannot be bound by a quantifier, and so cannot participate in anaphoric relationships.

Like the van Eijck & Cepparello 1994 system, then, this dynamic modal predicate logic incorporates worlds but is not a suitable system for modeling propositional anaphora. Like van Eijck & Cepparello 1994, it does not model propositions beyond the current context set, so there is no representation of discourse-relevant propositions which can serve as antecedents for anaphoric relations.

4.2.6 Update with Centering (Bittner 2009)

Update with Centering (UC; Bittner 2009), like PLA, is an update semantics, but one which "represents not only changing information but also changing focus of attention in discourse" (p. 1). PLA represents attention indirectly, in that some discourse referents are more prominent than others—in particular, the most recent ones, though that an object language pronoun is more likely to be translated as p_0 than as p_7 is a fact about the language, and not a feature of PLA itself. UC, in contrast, hard-codes those most prominent positions into the system, in a way we'll see shortly. And where PLA focused on individual discourse referents, UC vastly expands the number of types which it deals with.

In UC, a discourse tracks not only information but also attention, so the knowledge and context against which a sentence is interpreted is a *state of infotention*. "A state of infotention is a set of *lists* of prominence-ranked semantic objects that can currently antecede discourse anaphors. Refining PLA, a UC-list is structured into a top sub-list of prominence-ranked topical objects (in the current center of attention) and a bottom sub-list of prominence-ranked background objects (currently in the periphery)" (Bittner 2009: 2). Just as in PLA, we extend our state by adding new discourse referents and constrain it by ensuring that certain properties hold of referents under discussion. And our attention can be modified just as our information can, so Bittner 2009 also introduces operators which reorder these lists. Where PLA had a single list, UC has pairs of lists, where each pair describes a way (the assignments on) the world could be. And those lists now contain more than just individuals: they also contain events, states, times, worlds, and propositions. A fragment of UC is presented in Figure 7.

As we can already tell by the number of types handled by the system, UC does not abstract over tense the way many systems (including DPL and PLA) do, and it also is sensitive to the eventive/stative status of verbs. That, plus the two lists being managed,

makes the UC translation of a sentence much more comprehensive than its DPL or PLA equivalent would be. For example, Bittner 2009: (4) gives the sentence in (377a) the UC translation in (377b), which reduces to (377c).

(377) a. Jim is busy.

b. $^{\top}[x|x =_i \textit{jim}]^{\top};\ (^{\mathrm{P}}[\vartheta_{\top\omega}\top\varepsilon \leq_i \top\tau];[\top\omega \in \top\omega\|];([s|\textit{busy}_{\top\omega}\langle s, \textsc{ctr}\ s\rangle]^{\perp};$
$[\textsc{at}_{\top\omega}\langle\perp\sigma, \top\tau\rangle,\ \textsc{ctr}\ \perp\sigma =_i\ \top\delta]));\ ^{\top}[p|p = \top\omega\|]$

c. $^{\top}[x|x =_i \textit{jim}]^{\top};\ ^{\mathrm{P}}[\vartheta_{\top\omega}\top\varepsilon \leq_i \top\tau];[s|\textit{busy}_{\top\omega}\langle s, \top\delta\rangle, \top\tau \subset_i \vartheta_{\top\omega}s];\ ^{\top}[p|p = \top\omega\|]$

Stepping through (377b), the first box, $^{\top}[x|x =_i \textit{jim}]$ introduces Jim into the discourse in the $\top$-list, making him a topical individual (and in fact the most topical individual, being at the top of the $\top$-list). The second box, $^{\mathrm{P}}[\vartheta_{\top\omega}\top\varepsilon \leq_i \top\tau]$, represents the non-past tense presupposition carried by *is*, and ensures that the topic time ($\top\tau$) is no earlier than the perspective point (here, by default, the speech act time $\top\varepsilon$). No topic time has yet been introduced, so it is still the speech time, so this is satisfied. The third box, $[\top\omega \in \top\omega\|]$, represents the modality of the predicate, and asserts that the world of evaluation (the most prominent world $\top\omega$) is in the common ground ($\top\omega\|$), which "is trivially true in root clauses, where the evaluation world is the topic world" (Bittner 2009: 8). The fourth box, $[s|\textit{busy}_{\top\omega}\langle s, \textsc{ctr}\ s\rangle]$, adds a state of being *busy* to the background list, and the arguments of this state (its world, time and individual) are added by the fifth box, which identifies its world and time with the topic world and time ($\textsc{at}_{\top\omega}\langle\perp\sigma, \top\tau\rangle$) and its center with the topical individual ($\textsc{ctr}\ \perp\sigma =_i\ \top\delta$). The sixth and final box takes all of the topic worlds which meet this description and identifies them with a topical proposition ($[p|p = \top\omega\|]$). For a full derivation of each sequential update, see Bittner 2009.

One thing we can see about UC from this translation, in comparison to DPL and PLA, is that UC is compositional not just at the sentence level, but at the morpheme level. The tense presupposition and modal assertion of *is* are represented as distinct updates,

which in English are both part of the lexical meaning of *is*, but could easily be associated with specific morphemes in a language with richer verbal morphology; see Bittner 2009 for how UC can handle morphological encoding of mood in Kalaallisut. The simplified translation in (377c) effectively has one update associated with each word, plus an update for the proposition associated with the sentence which Bittner 2009 associates with the "full stop prosody" of the declarative mood.

The example in (377) also demonstrates how much of the UC system makes use of anaphoric relations. Every occurrence of $\top$ or $\bot$ references the topic lists, either updating them or checking new information against them. This use of anaphora is not just for individuals, but also for tense and modality, formalizing the observations of Partee 1973; Stone 1997 (as mentioned in Chapter 2). Even the naming of new propositional variables is anaphoric, as we saw with the final update of (377b/c), which refers back to the current set of topic worlds, and assigns that set a propositional variable.

In addition, as one might expect, Bittner 2009 translates English pronouns as anaphors. *I* and *you* are the center and experiencer, respectively, of the topical speech act event, where a third person pronoun like *he* is just the topical individual, either foregrounded ($\top\delta$) or backgrounded ($\bot\delta$). Bittner 2009 never explicitly mentions propositional anaphors, but presumably they could be translated in parallel, as $\top\Omega$ and $\bot\Omega$ (where Ω abbreviates ωt).

UC thus requires little in the way of structural modifications to be able to handle the data discussed in Chapter 3. Just as the declarative mood is taken to introduce a propositional discourse referent, so would sentential negation, epistemic modal auxiliaries, and certain embedding verbs. The way those propositional discourse referents were introduced must be a little different, however: where the declarative mood introduces a discourse referent for those topic worlds which have survived the informative update, negation, modal, and non-factive verbs) would have to introduce propositional discourse ref-

erents for sets of worlds which were entertained, but which were not identified with the common ground—and in the case of negation, which were disjoint from the common ground. Bittner 2011 models these propositional discourse referents as being stored on the $\perp$ list, independent of the representation of the context set in the $\top$ list.

The way the declarative mood discourse referent is added is slightly problematic, but for reasons unrelated to propositional anaphora. The UC declarative mood update makes all new asserted propositions subsets of the existing common ground, which has been argued to be undesirable in a theory of conversational update (see Murray 2010, 2014 on evidentials and Snider 2015 on tautologies). This could be ameliorated if discourse referents for matrix propositions were added to the $\perp$ list, like the prejacent of negation. The $\top$ propositional discourse referent would represent the context set, where the propositions which were intersected to derive that context set—as well as other propositions, like the prejacent of negation—would be stored in the $\perp$ list.[70]

Other than that, an extension of UC would simply require ensuring that the right morphemes were translated into UC with propositional discourse reference introduction updates. As we have already seen, Bittner 2009 has the declarative mood introduce a propositional discourse referent; the antecedent of a conditional is also translated as introducing a propositional discourse referent (Bittner 2009: (23)). In this example, though, the consequent does not, which given our observations in §3.4.7 would need to be amended.[71] A larger fragment of UC with an eye towards propositional anaphora would have to ensure that negation, epistemic modal auxiliaries, relative clauses, etc., would similarly have the update effect of adding a propositional discourse referent to one of the $\top\perp$-lists.

[70] As we'll see, this is precisely the approach taken in Murray 2010, 2014.

[71] The data on anaphoric reference to the consequent of a conditional from its antecedent also raise interesting questions for how cataphora could be handled in a system like UC, whose emphasis on morpheme-by-morpheme update renders it dependent on prior information in a way that makes forward-seeking anaphors troublesome. (Though, admittedly, DPL and PLA would similarly struggle with such data, nor was UC designed to handle cataphoric reference.)

4.3 Background on modeling propositions

In the previous section, we looked at systems which were developed to formally represent anaphoric relations, in particular between pronouns and their individual antecedents. The sort of system we would need to model the examples of propositional anaphora observed in the previous chapter would have representations not only of individuals mentioned in a discourse, but also of propositions, to serve as anaphoric antecedents. In this next section, then, we examine some systems which have formal representations of propositions.

4.3.1 Fine 1970

Fine 1970 considers the semantics S5 (Kripke 1959) and the nature of quantification over propositions. In particular, Fine 1970 contrasts three different conceptions of the set of propositions being quantified over: whether it is Boolean (closed under complementation and finite union), closed under formulas, or the power set of the set of worlds). A fragment of this system as presented in Fine 1970 is in Figure 8.

This system has propositional variables and universal quantification over propositions, but no means of tracking mentioned propositions as discourse referents; in fact, the system is not concerned with mention or discourse, as such, at all. There are other reasons why the Fine 1970 system is not ideal for our representation of propositional anaphora. For example, the propositional logic of this system means that propositional variables cannot be embedded under one another, where Chapter 3 suggested that we should want a single sentence of English to be able to introduce multiple propositional discourse referents. It is also not straightforward how to incorporate anaphors into such a system, where the 'contents' of a sentence are opaque once it has been translated (presumably) into a proposition.

4.3.2 Veltman 1996

Veltman 1996 introduces an update semantics to capture inferences of the form of (378).[72]

(378)

premise 1:	P's normally are R
premise 2:	x is a P
conclusion:	Presumably, x is R

(Veltman 1996: 225)

Despite the existence of x in (378), the logic of Veltman's (1996) update semantics is completely propositional, plus three propositional operators: *might*, *normally*, and *presumably*. Importantly, these operators take propositional arguments but don't output propositions, so they're not embeddable. "Sentences of the form *might* ϕ are not persistent; they do not express a proposition; their informational content is not context independent. If you learn a sentence ϕ of L_0^A, you learn that the real world is one of the worlds in which the proposition expressed by ϕ holds: the real world is a ϕ-world. But it would be nonsense to speak of the '*might* ϕ-worlds'. If ϕ might be true, this is not a property of the world but of your knowledge of the world" (Veltman 1996: 231). A fragment of the Veltman 1996 system is in Figure 9.

The Veltman 1996 system makes use of propositional variables in that all information about the world is propositional: atomic sentences, and sentences of L_0^A denote sets of worlds. Sentences of L_1^A and L_2^A involve propositions taken as arguments, but sentences involving *might*, *normally*, or *presumably* do not themselves denote propositions.

Despite these propositional variables, the Veltman 1996 system was not built for and cannot handle propositional anaphora. Thus there are no propositions which could easily be labeled as discourse referents for subsequent reference. It does not 'store' the propo-

[72] An earlier 1991 manuscript was circulated and cited, influencing for instance van Eijck & Cepparello 1994, so it appears earlier in this listing than its publication date suggests.

sitions involved in updating an information state in a list, nor are those propositions retrievable from the information state itself (s is a subset of W, it isn't derived from a generalized intersection of a set of accepted propositions, for instance). Reworking this system to handle propositional anaphora would require a complete reworking of the system: changing the way propositions are 'stored', introducing the anaphors, and making the output of L_1^A and L_2^A propositional (as sentences with *might*, *normally*, or *presumably* can of course be targeted by propositional anaphors).

4.3.3 Geurts 1998, 1999

Geurts 1998, 1999 models belief and attitude reports, presupposition, and modal subordination in DRT. However, Geurts (1998, 1999) differentiates his proposal from prior accounts of belief in DRT, including that of Asher 1993 among others. According to Geurts 1998: 569, Asher 1993 and others propose a "structural theory of belief": "belief is construed as a relation between an individual and a syntactic objects, i.e. a DRS". Instead, Geurts 1998: 570 construes belief as "a relation between individuals and sets of worlds", i.e., propositions.

In this system, rather than having attitude verbs like *believe* take DRS arguments, they take propositional discourse markers as arguments. Where on Asher's (1993) account a propositional discourse referent is only introduced if a subsequent clause contains a propositional anaphor, here a sentence containing an attitude verb introduces a propositional discourse referent immediately—in fact, it introduces two:

(379) a. There is an A who believes that there is a B.

b. [x, p, q: Ax, x believes p, x believes q, q = p + [y: By]] (Geurts 1998: (44))

The sentence in (379a) is translated into the DRS in (379b)—the structure is written out, as opposed to in the boxes we saw in Asher 1993, but the two are equivalent: the universe

of discourse referents precedes the colon, the conditions follow it. (379b) includes two propositional discourse referents, p & q, where p represents the contents of x's beliefs *not including* the content being discussed (namely, 'there is a B') and q represents the sum of x's beliefs, including both p and the stated belief. A fragment of Geurts's (1998) extension to DRT is in Figure 10.

Moving away from a "structural theory of belief" solves the problems surrounding the assumption that all and only (sub)DRSs are available antecedents for propositional anaphora, as discussed in §4.2.2. It raises its own problems, though. Geurts 1998, 1999 is not interested in anaphoric reference to the propositional variables it introduces, so it makes some incorrect predictions.

As we saw in §3.4.4, sentences like (379a) make two propositions available for anaphoric reference: (i) the proposition denoted by the matrix clause, and (ii) the proposition denoted by the embedded *that* clause. The representation in (379b), however, introduces two propositional discourse referents, but not these two. Neither (379b)'s p nor q represents the proposition denoted by the *that* clause (call it r): p represents x's beliefs not including r; q represents all of x's beliefs, including r, but also including everything else x believes. Neither of these propositions, however, are available for reference by a propositional anaphor:

(380) Jonathan believes that Nancy was at the party. He told Joyce *that*.

a. # He didn't tell her anything about Nancy, however.

b. However, he didn't tell her that he believes Barb was also there.

The first sentence in (380) contains a simple assertion about belief, parallel to (379a) except with names, and the second sentence contains a propositional anaphor. Just to reiterate, in this context our r would be the proposition 'Nancy was at the party', Geurts's (1998) p would be Jonathan's beliefs not including r, and q would be all of Jonathan's beliefs:

p+r. The follow-up in (380a) asserts that Jonathan didn't tell Joyce r, which rules out q as a possible antecedent for *that* as all q-worlds are r-worlds. This interpretation would still leave p as a possible antecedent—Jonathan could tell Joyce p without mentioning Nancy—but this follow-up is infelicitous, suggesting that in fact p is not an available antecedent. The follow-up in (380b) asserts that Jonathan didn't tell Joyce about one of his other beliefs s, where p⊆s (if p represents Jonathan's prior belief worlds, then all p-worlds are s-worlds). If all p-worlds are s-worlds, then telling Joyce p amounts to telling her s as well, so this follow-up is incompatible with p as the antecedent of *that*. In fact, it is incompatible with q as an antecedent as well, since q⊆p⊆s. This follow-up is felicitous, however, which suggests that there is some available antecedent for *that* other than p or q. Neither of the propositional discourse referents introduced in a belief report in Geurts; Geurts's (1998; 1999) system is actually available for anaphoric reference. The proposition denoted by the *that* clause, which *is* available for anaphoric reference, does not get a propositional discourse referent on this analysis.

Geurts 1999 has the same two propositional discourse referents introduced for other attitude predicates like *want*.

(381) a. Professor Müller wants to play the accordion.

b. [x, p, q: PM x, x considers p, q = p+[x: x plays the accordion], x prefers$_p$ q]

(Geurts 1999: (70))

"[(381a)] takes some set of alternatives [to x's doxastic worlds] as given and asserts of this set, represented here by the reference marker p, that professor Müller prefers all p-worlds in which he plays the accordion to any p-world in which he does not" (Geurts 1999: 170f.). Regardless of the presupposed status of p in (381b), neither p nor q are available for anaphoric reference, and, as we saw in §3.4.1, neither is the complement of *want* (here represented by the subDRS [x: x plays the accordion]).

(382) a. # Professor Müller wants to play the accordion because he doesn't believe that.

b. Professor Müller wants to play the accordion because his sister doesn't believe that he can.

Geurts 1999 treats finite and non-finite complements equivalently in terms of the introduction of propositional discourse referents, which is problematic given the data observed in Chapter 3. Moreover, the predictions this analysis makes for the anaphoric potential of both finite and non-finite complements are not borne out by the data. Moving away from the structural account of Asher 1993 might be beneficial for other reasons, but the account given in Geurts 1998, 1999 does not get us closer to modeling the phenomenon we're interested in here.

4.3.4 Stone & Hardt 1999

Stone & Hardt 1999 is interested in cases of sloppy identity, especially involving tense and modals, as in (383).

(383) a. You thought I was crazy. You probably still do.

b. John would use slides if he had to give the presentation. Bill would just use the chalkboard. (Stone & Hardt 1999: (4))

Stone & Hardt 1999 proposes an extension of Muskens 1995b (CDRT) which has "simple discourse referents with values of type **e** (introduced by NPs), τ (introduced by tense), ϵ (introduced by VP), as well as (**wt**) (introduced by mood)." (Stone & Hardt 1999: 303) The system also has dynamic discourse referents for all of these types, so as to account for sloppy identity. A relevant segment of the system laid out in Stone & Hardt 1999 is provided in Figure 11.

Stone & Hardt make use of these discourse referents in defining dynamic transitions, of the same type as DRT boxes, with their $\mathbf{if}(\omega_1, \omega_2, K)$ operator, where ω is a variable over "world-set markers"—that is, for our purposes, a variable over propositions. This operator introduces a discourse referent for ω_2 into the discourse context before relating it to the rest of the model. And, because both *not*, *may*, and *might* are translated into the system as terms which include $\mathbf{if}(\omega_1, \omega_2, K)$ statements, both negation and modality in the Stone & Hardt 1999 system both (i) introduce a propositional discourse referent for their prejacent propositions, and then (ii) are anaphoric on a proposition, as they relate ω_2 to ω_1.

As we will see, the system proposed here captures this same flavor: both negation and modality introduce discourse referents for their prejacent propositions, and make reference to that discourse referent as they impose further constraints on their interpretation.

There are some differences between the Stone & Hardt 1999 system and the sort of system that we would like to capture the data presented in Chapter 3, however. Because they are interested in modality, Stone & Hardt talk about these "world-set markers" as representing modalities; for example, the outermost (**wt**) discourse referent introduced for the assertion of a conditional is ω_0, which is described as "representing reality", introduced by the verbal mood marker POS (Stone & Hardt 1999: 307). (In contrast, recall that Bittner's (2009) Update with Centering has the outermost propositional discourse referent associated with sentential mood, not verbal mood.) We want the 'outermost' discourse referent—the one associated with the matrix clause of a declarative sentence—to represent a set of worlds, but not necessarily one associated with reality.

In addition, while the Stone & Hardt 1999 **if** operator introduces a propositional discourse referent for the antecedent of a conditional, it does not introduce a parallel one for the consequent. Stone & Hardt 1999 is thinking of these "world-set markers" as representing modalities, potential antecedents for modal anaphora, not as antecedents for the sort

of propositional anaphora we're interested in here. If this system were to be expanded to cover the data we observed in Chapter 3, however, we would need a discourse referent for the consequent of a conditional as well.

4.3.5 Aloni 2007

Aloni 2007 is interested in the different behavior of modals and imperatives as they license free choice *any* and free choice disjunction. To model this difference, Aloni 2007 introduces a logic for representing alternatives: a modal predicate logic with propositional quantifiers, building on Fine 1970 and Dekker 2002. A fragment of this system is in Figure 12.

On this account, *any* and *or*—represented formally as $\exists$ and $\vee$, introduce sets of alternative propositions. When propositional quantification interacts with either individual quantification or disjunction, the nature of these alternative sets can differ, as in (384) & (385). For example, if the propositional variable p is identified with the entire individual quantification, as in (384a), then the alternative set introduced is a singleton set, as in (384a′); if p is identified with the nuclear scope of $\exists x$, as in (384b), then the alternative set is a "genuine set of alternatives" (74), as in (384b′).

(384) (Aloni 2007: (19))

a. $\exists x A(x) / \exists p(p \wedge p = \exists x A(x))$

a′.

$\exists x A(x)$

b. $\exists p(p \wedge \exists x(p = A(x)))$

b′.

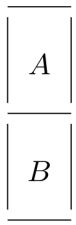
$A(d_1)$
$A(d_2)$
$\ldots$

(385) (Aloni 2007: (20))

a. $A \vee B / \exists p(p \wedge p = A \vee B)$

a′. 

b. $\exists p(p \wedge (p = A \vee p = B))$

b′. 

This distinction allows Aloni 2007 to capture the behavior of modals and imperatives, which are analyzed as involving quantification over these alternatives.

This formal system, though it contains propositional variables, is not very amenable to representing propositional anaphora. Aloni 2007 conceives of these propositional variables as useful for generating alternative sets, not for representing discourse referents. This results in an equivalence which is visible in the presentation of (384a) & (385a). "$\exists p(p \wedge p = r)$, and r are truth conditionally equivalent. They also induce the same alternative set. The use of a propositional quantifier does not add anything in this case." (Aloni 2007: 73f.). This equivalence means that there is no difference between a formula that is assigned a propositional variable and one that is not, which means that we cannot hope to use these propositional variables to represent discourse referents.

Even beyond this equivalence, the propositional variables introduced in the Aloni 2007 system do not neatly map onto the propositions that we want to be assigned discourse referents, given the observations in Chapter 3. For example, consider the representation of disjunction in (385). It is a question of interpretation, whether a particular disjunction is understood as having a propositional variable assigned to the entire disjunction (as in (385)a), or assigned disjunctively (as in (385b)). As we saw in §3.5.2, though, a representation of the anaphoric potential of a disjunction would require propositional discourse referent for each disjunct *and* for the matrix disjunctive clause: it is not a question of interpretation, nor would we want a single disjunctive referent for (one of)

the disjuncts. This logic of alternatives also leads Aloni 2007 to assign a propositional variable to a *wh-* question, as in (386b).

(386) (Aloni 2007: (22))

a. Who smokes?
b. $?\exists p(p \wedge \exists x(p = A(x)))$

b′.

$A(d_1)$
$A(d_2)$
$\ldots$

As we saw in §3.3.2, though, this propositional variable cannot be understood to represent a discourse referent, as *wh-* questions do not make any proposition available for anaphoric reference. The Aloni 2007 system, then, cannot be easily extended to model propositional anaphora.

4.3.6 Murray 2010

Murray 2010, 2014 uses UC (Bittner 2009, 2011; see §4.2.6) to model the different at-issue and not-at-issue contributions of different kinds of content, including sentences with evidentials, parentheticals, and appositives. For a fragment of this system, see Figure 7; see also the appendix of Murray 2014. On this account, at-issue content is presented as a proposal to update the discourse context, including the common ground, where not-at-issue content updates the discourse context directly, with no proposal. As represented in UC in Bittner 2011, the assertion of at-issue content introduces a propositional discourse referent into the $\perp$ list, but does not restrict the context set—represented as a propositional discourse referent in the $\top$ list—at least until a subsequent acceptance update. The assertion of not-at-issue content, meanwhile, imposes a restriction on the context set directly, and so needn't necessarily be represented with a propositional discourse referent.

For example, the propositions associated with the Cheyenne evidentials discussed in Murray 2010, 2014 are not available for subsequent anaphoric reference, so they are not assigned a propositional discourse referent on this account. Murray 2010, 2014 discusses whether this behavior is linked to the at-issue status of Cheyenne evidentials, which Murray argues are grammatically marked as being not-at-issue. For now, we leave aside the question of how at-issueness relates to anaphoric potential; we will explore this matter in more detail in Chapter 5. The Murray 2010, 2014 UC system is compatible with the introduction of propositional discourse referents for not-at-issue content as well. Such discourse referents would presumably also be added to the $\perp$ list, just like the discourse referents associated with at-issue content.

The introduction of propositional discourse referents in the $\perp$ list, as described in Murray 2010, 2014 following Bittner 2011, brings us closer to our goal of modeling propositional anaphora over the implementation described in Bittner 2009, which only describes introducing a propositional discourse referent for the context set. Having propositional discourse referents for content which extends beyond the context set, or which is disjoint from it, allows us to model anaphoric reference to embedded clauses, the prejacent of negation, etc., and not just to the current context set. This also captures the sense in which sentential negation is anaphoric on its prejacent, as described in Stone & Hardt 1999. The introduction of discourse referents for not just the context set but also for the prejacent of negation (Bittner 2011) and for asserted content (Murray 2010, 2014) suggests one way UC can model propositional anaphora.

4.3.7 AnderBois et al. 2013

AnderBois et al. 2013 is interested in the at-issue and not-at-issue content of English sentences containing appositive relative clauses, and in particular how anaphora and pre-

supposition can allow these different types of content to interact.[73] Like Murray 2010, 2014, AnderBois et al. 2013 models different update procedures for at-issue and not-at-issue content: not-at-issue content (e.g., contributed by an appositive) directly updates the common ground, after which at-issue content introduces a proposal to update the (now-restricted) common ground. They model these updates in a dynamic semantics based on DPL (Groenendijk & Stokhof 1991). A fragment of this system is in Figure 13.

In this system, the context set is represented by a propositional variable p^{cs}, as is the new proposal p put forward by some at-issue content. Upon its introduction, p gets a random variable assignment from subsets of the current context set, and then as information is gained, the cases of p are narrowed down. If the proposal is accepted, p is set as the new p^{cs}. Appositive content, on the other hand, is not assigned a propositional variable, and updates p^{cs} directly.

As it stands, we cannot understand the propositional variables in AnderBois et al. 2013 as representing propositional discourse referents: no variable is assigned to the content denoted by an appositive relative clause, but the data in §3.4.5 showed us that appositive relative clauses are available for anaphoric reference.[74] The AnderBois et al. 2013 system could be amended, however, to introduce propositional variables to appositive (and perhaps other not-at-issue) content. The difference between at-issue and not-at-issue content, then, would not be the presence or absence of a propositional variable, but whether the subsequent update was automatic (for not-at-issue content) or was subject to acceptance, interlocutor negotiation, etc. (for at-issue content). We will return to a discussion of at-issueness and its connection to anaphoric potential in Chapter 5.

Another consequence of this system is that all propositional variables introduced are

[73] An earlier version of this work was published as AnderBois et al. 2010.

[74] AnderBois et al. 2013 notes that sentence-final appositives are available for direct rejection via response particles, where sentence-medial ones are not (but see Syrett & Koev 2015; Hunter & Asher 2016). To the extent that this is true, that data, coupled with the observations in §3.4.5, indicate that response particles may be more restricted in their use than other propositional anaphors, not that appositives are not available for anaphoric reference.

subsets of the context set. This has been previously argued to be undesirable (see Murray 2010, 2014 on evidentials and Snider 2015 on tautologies), and would be further problematic for representing propositional anaphora. If some variable new p were a subset of p^{cs}, and the proposition q had already been accepted into the common ground, then a statement like *Nancy told Steve that*, where *that* referred to p, would amount to saying that Nancy told Steve not only p but also q (because $p \subseteq p^{cs} \subseteq q$, so p entails q). This doesn't reflect how we interpret such anaphors, so we wouldn't want our model to make such equivalences.

4.3.8 Murray & Starr 2016

Murray & Starr 2016 is interested in the semantics for sentential mood, and how it relates to sentential force. Murray & Starr 2016 models this with a dynamic semantics that tracks both propositional discourse referents and preference states, so as to unify the update functions of declaratives, interrogatives, and imperatives (and the conjunctions thereof). A fragment of the Murray & Starr 2016 system is presented in Figure 14.

The Murray & Starr 2016 system tracks discourse referents for propositions in its states, in an ordered list along the lines of Dekker 1994 (and thus also Bittner 2009, 2011). However, the core of the system presented in Murray & Starr 2016 is a propositional logic, translating sentences into (moodless) atomic expressions, and as a result does not represent embedded clauses or subclausal constituent structures, which as we saw in Chapter 3 are sometimes relevant for propositional anaphora. It handles some of the operators which introduce propositional discourse referents for their arguments, including sentential negation, conjunction, disjunction, and (some) sentential mood(s). For these operators, the Murray & Starr 2016 system could be extended to also represent the discourse referents they introduce. [75] It would be considerably more complicated, however,

[75] Presumably the same is true for modal operators $\Diamond$ and $\Box$, which are not discussed in Murray & Starr 2016 but are frequently represented as sentential operators.

to extend the propositional logic of the Murray & Starr 2016 system to account for the propositional discourse referents introduced by embedded clauses and other subsentential constructions.

4.4 A new formal system

In this section, I propose a new formal system to model the behavior of propositional anaphora as observed here and in previous chapters. I will begin with simple examples, and show how this system can be be expanded to handle progressively more complex cases in subsections §4.4.2, §4.4.3, & §4.4.4. Subsections §4.4.5 & §4.4.6 discuss some limitations of this system. This section will not model every example from previous chapters, but should be sufficient to demonstrate the shape of the system and its capacity.

4.4.1 Simple sentences

Like Groenendijk & Stokhof 1991; Aloni 2007, this system will have propositional variables introduced by an existential quantifier, those variables operating as discourse referents.. These discourse referents won't be stored in an ordered list as in Dekker 1994, 2012, or a pair of lists, as in Bittner 2009, 2011. Anaphors will be translated as free variables, which will be dynamically bound, as in DPL. Propositional variables will be identified with their contents using identity, as in Aloni 2007. In the examples that follow, English constructions which have an associated propositional discourse referent will be transcribed with that variable superscripted, and anaphors will be subscripted with the variable they are bound by. Like Bittner 2009, 2011 and Murray 2014, we will have the declarative mood contribute a propositional discourse referent, and like Stone & Hardt 1999 we will analyze sentential negation as anaphoric on its prejacent.

One major point of departure between the system proposed here and the systems reviewed above is in how propositions are represented. For one thing, we want to be

explicit about the fact that events are interpreted relative to worlds. More importantly, however, we want to encode that an embedded propositions might be interpreted relative to different worlds than the proposition denoted by the whole sentence. In a sentence like *Dustin believes Joyce napped*, the proposition denoted by the embedded clause is evaluated relative to Dustin's belief worlds, where the matrix clause proposition is evaluated relative to the worlds under consideration as part of the discourse (in particular, to the distinguished world, the actual world). In order to capture this, we add not only world variables $w, w', w'' \ldots$ of type s but also a lambda abstraction operator λ to bind them. In this system, declarative sentences are interpreted relative to worlds, so the translation of a declarative sentence will always start with λw. This introduces a complication: on a static possible-worlds semantics, a declarative sentence denotes a function from worlds to truth values; on a dynamic semantics like DPL, a declarative sentence denotes a relation between sets of assignment functions. A fully dynamic version of this system would involve a dyanamic λ operator, along the lines of Ty_2 (Gallin 1975; see Figure 15) with added propositional variables, but I have not implemented that here. As it stands, the system proposed here encloses the DPL-style dynamics in a static wrapper. Where in DPL a declarative sentence denotes a relation between sets of assignment functions, this proposed system has declarative sentences denote functions from worlds to relations between sets of assignment functions. We interpret a declarative sentence as true relative to a world of evaluation and an input assignment if and only if there is some output assignment relative to this pair that makes the proposition described by the sentence true at that world.

The guiding principles that underlie this system can be described as follows: (a) propositional variables are assigned only to every proposition which is available for subsequent anaphoric reference; and (b) a propositional variable is introduced for a given linguistically-encoded proposition by the operator which takes it as an argument. Because propositional variables are introduced by the existential quantifier $\exists$, such

proposition-taking operators will be understood in this system as contributing $\exists$ to the translation of a sentence.

As we saw in Chapter 3, the matrix clause of a declarative sentence is available for anaphoric reference. The propositional discourse referent for this clause will be introduced by the declarative mood operator DECL, parallel to Bittner 2009, 2011 and Murray 2014. A simple sentence like (387a), understood as in (387b), will get the translation in (387c).

(387) a. Joyce napped.

b. DECL [Joyce napped.]^{p}

c. $\lambda w \exists p.p = [\lambda w'.N(w', j)] \wedge p(w)$

Under the lambda abstracting over worlds, we have two conjoined terms. The first term, $\exists p.p = [\lambda w'.N(w', j)]$, involves a dynamic variable binder $\exists$, which just as in DPL will introduce a discourse referent. Here, however, it is a propositional discourse referent, p. As in DPL, $\exists$ changes the dynamic assignment, here ensuring that the variable p gets mapped to something by the output assignment function. By means of propositional identity $=$, this discourse referent p is associated with $\lambda w'.N(w', j)$, the set of worlds w' where Joyce napped. (Recall that events are modeled here as being interpreted relative to worlds, where individuals are not.) The second conjunct, $p(w)$, represents the assertion of p, that the world of evaluation is one of the p-worlds. So the sentence first introduces a propositional variable as a discourse referent, and then uses that variable to assert the truth of its contents: both of these are contributions of the declarative mood marker DECL. The sentence is true, relative to a world of evaluation w and an input assignment f, just in case there is an output assignment g such that g differs from f just in that it maps p to $[\lambda w'.N(w', j)]$, and w is a world in which Joyce napped.

4.4.2 Sentential negation

Not every proposition which has an associated discourse referent is asserted to be true, of course. The prejacent of sentential negation, as we have seen, has an associated propositional discourse referent (Krifka 2013) even though it is certainly not a commitment of the speaker. In our system, the propositional discourse referent for the prejacent of negation will be introduced by the negation operator NEG, while the matrix negated proposition will again be introduced by the declarative mood DECL. NEG, like DECL, will use $\exists$ to introduce its propositional variable, though unlike DECL it will not then assert the truth of its argument. We should want a sentence like (388a), understood as in (388b), to get a translation as in (388c).

(388) a. Joyce didn't nap.

b. DECL [NEG [Joyce napped.]^{q}]^{p}

c. $\lambda w \exists p \exists q.q = [\lambda w'.N(w', j)] \wedge p = [\lambda w''.\neg q(w'')] \wedge p(w)$

By convention, the discourse referent for the outermost proposition, the one denoted by the matrix clause, will be assigned the variable p, where embedded propositions in a single clause will get q, r, p', etc., from least-embedded to most-embedded. World variables will be assigned w, w', etc., in the order as required by the translation. And for ease of reading, I have moved both existential quantifiers to the beginning of (388c)—I will return to this in §4.4.5. For now, consider the three terms under the lambda abstraction.

The first, $\exists q.q = [\lambda w'.N(w', j)]$, is NEG's introduction of a discourse referent for its prejacent proposition. The second, $\exists p.p = [\lambda w''.\neg q(w'')]$ is the introduction of the discourse referent for the matrix clause. In this term, the $\exists$ is contributed by DECL, and the $\neg$ in its nuclear scope contributed by NEG. Note that what defines the character of the content being negated here is the discourse referent representing the prejacent (along with a vari-

able over worlds). In this sense, sentential negation is an anaphoric process, as it was in the Stone & Hardt 1999 system. Finally, the third term, $p(w)$, asserts the truth of p—which will be expanded to $\lambda w''.\neg q(w'')$— in w.

This order of terms makes a sort of intuitive sense if we're considering this representation as being built bottom-up: first we translate the prejacent of negation, then the higher negated clause, and finally the assertoric force of the utterance. This intuition, however, presupposes a finer grain of compositionality than has been provided just yet: this system, like DPL, is compositional at the *sentence* level, not the morpheme level. We will return to a discussion of compositionality in §4.4.5; for now, let us move on to propositional attitude verbs.

4.4.3 Embedding verbs

As we saw in §3.4.4, the propositions denoted by the finite (*that* clause) complements of embedding verbs like *say* and *believe* are available for anaphoric reference. These complements denote propositions which are taken as arguments by these embedding verbs. In our system, this means that verbs like *say* and *think* must also contribute an existential quantifier into the translation of a sentence they appear in. For example, the sentence in (389a), understood as in (389b), is given the translation in (389c).

(389) a. Dustin said (that) Joyce napped.

b. DECL [Dustin said [(that) Joyce napped.]^{q}]^{p}

c. $\lambda w \exists p \exists q.q = [\lambda w'.N(w', j)] \wedge p = [\lambda w''.S(w'', d, q)] \wedge p(w)$

Just as we have seen above, the first term of (389c) associates a discourse referent with the proposition denoted by the complement of *said*, the second term associated a discourse referent with the matrix clause proposition, and the third term asserts the truth of that matrix clause proposition.

Just like the negated sentence in (388c), the translation of the report in (389c) introduces a discourse referent for the proposition denoted by the complement clause, and in both cases that complement is not asserted to be true. A sentence like (389a) can be used to convey the truth of the complement proposition (here, that Joyce napped), as in (390), in a way that is not available for the prejacent of negation.

(390) Dustin said (that) Joyce napped, so I asked her how her nap was.

(391) # Joyce didn't nap, so I asked her how her nap was.

The speaker of a sentence like (389a) can commit herself to the truth of the complement clause proposition, but that is not an entailment of the sentence: (392) is perfectly coherent (and thus felicitous).

(392) Dustin said (that) Joyce napped, but *that*'s not true. (She's been up for hours.)

(393) # Joyce didn't nap, but *that*'s not true.

In contrast, the prejacent of negation cannot be a commitment of the speaker without rendering the discourse absurd: the matrix clause commits the speaker to the falsity of the prejacent proposition. (And if the anaphor in (393) targets the prejacent proposition, the second clause is redundant and the contrast required by *but* is not satisfied, hence infelicity.) So even though the complement of a report *can* be understood as a speaker commitment, that stronger reading is not part of the translation of the sentence into the system.

Sentences with multiple embeddings using such verbs are felicitous, and such sen-

tences can be easily translated into the system along the same lines:

(394) a. Barb thought (that) Dustin said (that) Joyce napped.

b. DECL [Barb thought [(that) Dustin said [(that) Joyce napped.]^{r}]^{q}]^{p}

c. $\lambda w \exists r \exists q \exists p . r = [\lambda w' . N(w', j)] \wedge q = [\lambda w'' . S(w'', d, r)] \wedge p = [\lambda w''' . T(w''', b, q)] \wedge p(w)$

Here, neither embedded clause proposition q nor r are asserted to be true: either or both could be taken as commitments of the speaker, but either or both could also be negated, so only p is translated as affecting the truth conditions of the sentence.

4.4.4 Relative clauses

As we saw in §3.4.5, the propositions conveyed by relative clauses are available for anaphoric reference. This is the case for both restrictive and non-restrictive relative clauses, though the accessibility of the former is more restricted; I will focus on non-restrictive relative clauses for present purposes. Given our generalization, a relative clause must be the argument of an operator—call it REL—where that operator introduces a discourse referent for the proposition conveyed by the relative clause.

A sentence containing a relative clause, then, will have propositional discourse referents associated with both the matrix and relative clauses. And, because both propositions are commitments of the speaker, both will update the truth conditions of the sentence. A sentence like (395a), then, understood as in (395b), will get the translation in (395c).

(395) a. Joyce, who won the race, napped.

b. DECL [Joyce, REL [who won the race,]^{q} napped]^{p}

c. $\lambda w \exists p \exists q . q = [\lambda w' . W(w', j)] \wedge p = [\lambda w'' . N(w'', j)] \wedge q(w) \wedge p(w)$

As we have seen with the examples above, the first two terms of (395c) introduce

discourse referents for the propositions associated with the relative and matrix clauses, respectively. Unlike with negation and embedding verbs, however, the matrix clause translation is not anaphoric on the embedded clause: the character of p does not reference q. And, unlike negation and embedding verbs, the translation in (395c) has four terms, as the non-matrix clause proposition here is asserted, where neither the prejacent of negation nor the proposition denoted by the complement of an embedding verb like *say* are commitments of the speaker. In (395c), both the third and fourth terms use the newly-introduced propositional discourse referents to assert the truth of their contents in the world of evaluation, as the relative clause proposition is just as much a commitment of the speaker as the matrix clause proposition.

We will discuss the relative statuses of these propositions in §4.4.6, but first, let us return to the compositionality of this system as it has been sketched thus far.

4.4.5 Compositionality

As mentioned above, this system at present is compositional at the sentence level—just like DPL—but not at the morpheme level. Having a system which could identify the contributions of individual morphemes, especially around the introduction of propositional discourse referents, is clearly preferable. Is such a system feasible, given our design parameters?

To make this system compositional at the morpheme level, we would first assign DECL the translation in (396), so as to ensure that (387a) received the translation in (387c) as desired.

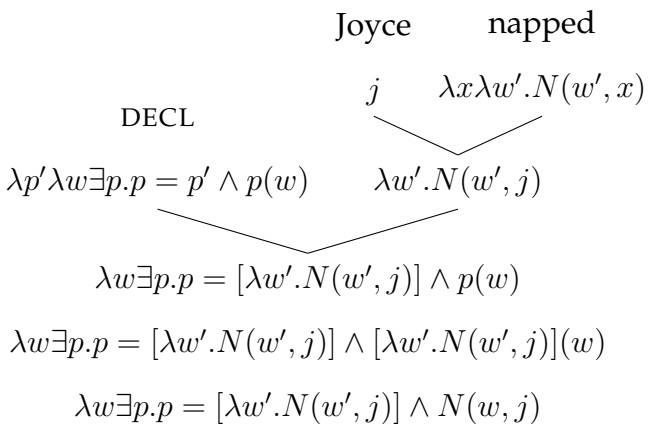
(396) $[\![\text{DECL}]\!] = \lambda p' \lambda w \exists p.p = p' \wedge p(w)$

This mood operator, type $(st)st$, takes a propositional argument, introduces a discourse

referent for that proposition, and asserts its truth (in w). Here I give the last term the newly assigned variable p as opposed to the argument p' to emphasize the contribution of DECL, and to reiterate the notion that update happens *after* the new discourse referent is introduced, and not before it (in contrast to UC); this is just a notational difference, however, as identity makes the two formulations equivalent.

Assuming that events are indexed to worlds but for simplicity that individuals are not, we would derive the translation in (387c) for the simple declarative sentence in (387a) as in (397):

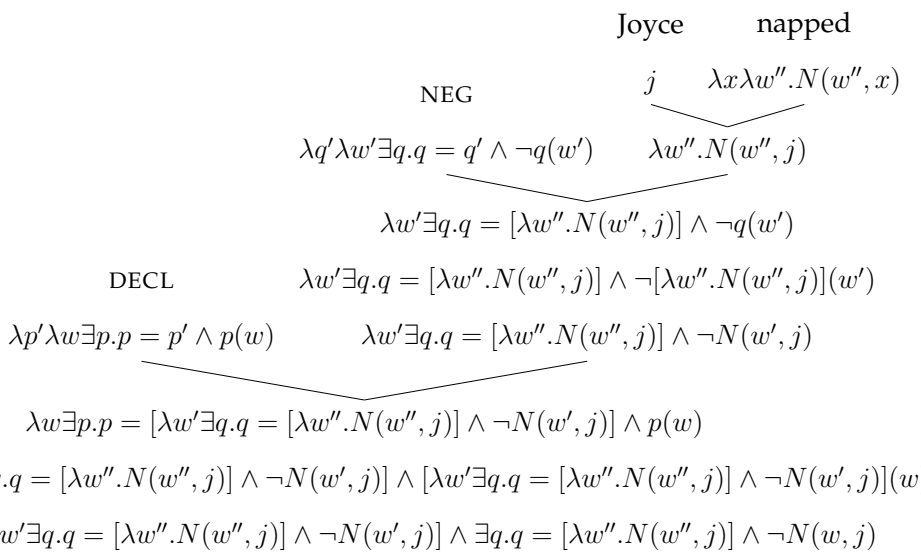
(397)



This derivation is fairly straightforward, and produces exactly the translation we had wanted. The clause *Joyce napped* denotes a proposition—in fact, the same proposition we want the sentence to assert, but we could stipulate that a clause (even a proposition-denoting clause) does not constitute a full sentence without sentential mood. It is the mood operator which introduces the propositional discourse referent for its argument, and only then is that proposition asserted.

Given our guiding principles, we should want NEG to have a similar translation to DECL: it must also be $(st)st$, and also contain $\exists$ to introduce a discourse referent for its prejacent proposition. And so, given the translation we would want to derive, we would build a tree for the negated sentence (388a) compositionally as in (398).

(398)



This derivation raises two points worth noting.

First, the translation of NEG (isolated in (399)) is strikingly parallel to that of DECL.

(399) $[\![\text{NEG}]\!] = \lambda q' \lambda w' \exists q.q = q' \wedge \neg q(w')$

The only difference between the two is the presence of $\neg$ in the final term. And where we think of the final term of DECL as representing the assertive contribution of the declarative mood, the final term of NEG has no such assertoric force and yet it looks suspiciously similar. The only difference between the terms $p(w)$ and $q(w')$ that results in the former, but not the latter, having the function of an assertive update, is that the proposition associated with the matrix clause takes the outermost world variable w as its argument, where the proposition associated with the prejacent of negation takes a different world variable, one which happens not to percolate up to the same level. In short, we cannot identify the assertoric force of a term by its translation alone, but have to consider it in context.

Second, consider the final (bottom-most) line of the derivation in (398), especially in comparison to the translation we gave in (388c). One thing we can note is that the order of the terms is different: (388c) assigns a discourse referent to the prejacent proposition

first, and then the matrix proposition, while in (398) that order is reversed. (In (388c) the existential quantifiers were in the same order, due to my transposition, but the identity statements were reversed.) More important, however, is that the matrix clause terms are not identical. Because of the nature of the composition, p in (398) has 'captured' the assignment of q as well, underlined in (400a)—call this duplicate instance q_2 for clarity, though both qs in the final line of (398) have disjoint scopes.

(400) a. $\lambda w \exists p.p = [\lambda w' \underline{\exists q_2.q_2 = [\lambda w''.N(w'', j)]} \wedge \neg N(w', j)] \wedge \exists q_1.q_1 = [\lambda w''.N(w'', j)] \wedge \neg N(w, j)$

b. $\lambda w \exists p.p = [\lambda w' \neg N(w', j)] \wedge \exists q_1.q_1 = [\lambda w''.N(w'', j)] \wedge \neg N(w, j)$

There are no instances of w' within the assignment of q_2 (as underlined), and there are no other instances of q_2 within the assignment of p: q_2 has been captured by p but only incidentally, as it is not used further. If we were to remove this underlined section, we would be left with the simplified (400b), which appears quite similar to (388c), albeit with the order of terms still rearranged.

We might be tempted to assert that it is simply a rule of this system that the introduction and assignment of propositional variables under a λw can be freely ignored if that assignment doesn't contain an instance of w. But of course this rule would also result in the removal of the assignments of p and q_1 in (400b) as well, as both are under λw but contain no ws. This would leave us with the correct truth conditions but neither of the propositional discourse referents which were the goal of this system to begin with.

We might instead say that discourse referent assignments *within the scope of* other discourse referent assignments are freely ignored. This would get rid of the underlined section in (400a) without affecting the other two propositional discourse referents. This rule, while effective here, is at least inadequate, if not pernicious. The only reason this rule works is because the translation of DECL copies its argument into the 'top-level', as

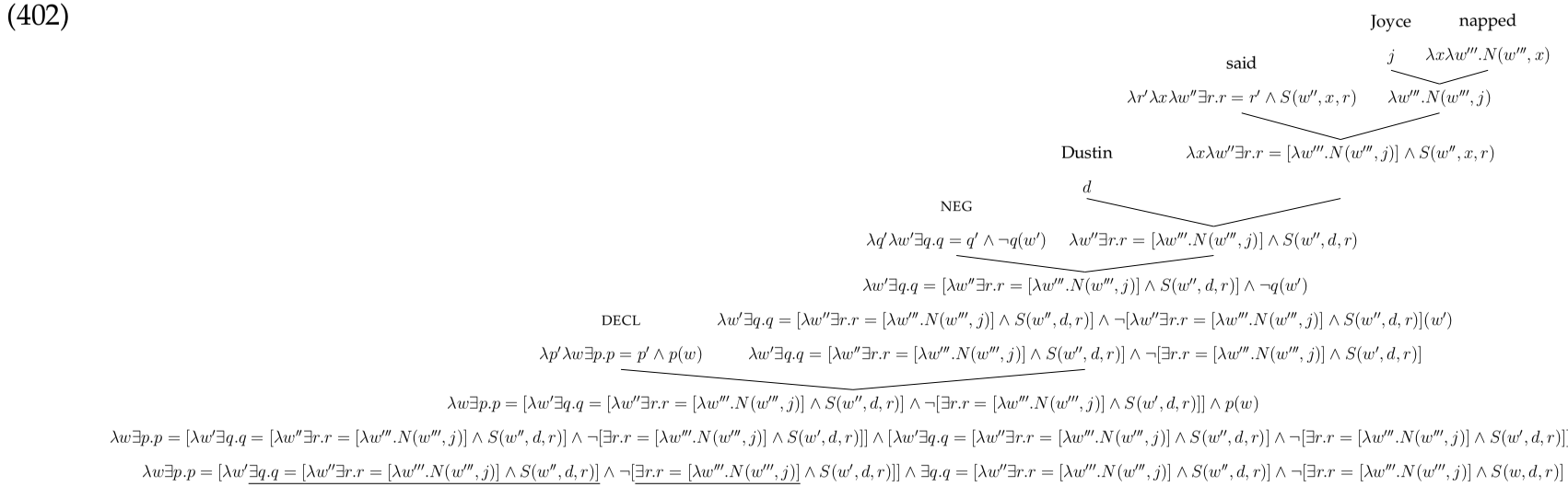
though it were no longer embedded, combining it with the evaluation world variable w. This makes the discourse referent introduced under the scope of DECL—the discourse referent for the prejacent, introduced by NEG—appear to be on the same 'top-level' footing. NEG, on the other hand, copies it only under the scope of $\neg$, so any propositional discourse referents introduced (not *by* but) *under* the scope of NEG will not be on this same 'top-level', but instead will stay under neg. We will see an example in a moment, but for that we need a translation for an embedding verb on this same compositional approach.

(401) $[\![\text{said}]\!] = \lambda r' \lambda x \lambda w'' \exists r.r = r' \wedge S(w'', x, r)$

An embedding verb like *said* takes a proposition, an individual, and a world, introduces a discourse referent for its propositional argument, and then says that the individual said the proposition in that world. So for a sentence like *Dustin didn't say Joyce napped*, our tree would look like (402).[76]

[76]In this derivation, I expand and replace occurrences of p and q as above, but leave r unexpanded. I do this for two reasons. First, p and q are fed world variables, and thus seeing their respective λ terms makes the derivation more transparent; r does not take an argument, so it is never further reduced. Second, is for reasons of space. There are four occurrences of (the introduction and subsequent use of) r in the final line of the derivation: expanding q doubles it, as NEG contains two instances of q, and the same for DECL and p. I therefore leave r unexpanded to make the tree easier to read.

(402)


Joyce
napped
j
$\lambda x \lambda w'''.N(w''', x)$
said
$\lambda r' \lambda x \lambda w'' \exists r.r = r' \wedge S(w'', x, r)$
$\lambda w'''.N(w''', j)$
Dustin
$\lambda x \lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', x, r)$
d
NEG
$\lambda q' \lambda w' \exists q.q = q' \wedge \neg q(w')$
$\lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', d, r)$
$\lambda w' \exists q.q = [\lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', d, r)] \wedge \neg q(w')$
DECL
$\lambda w' \exists q.q = [\lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', d, r)] \wedge \neg [\lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', d, r)](w')$
$\lambda p' \lambda w \exists p.p = p' \wedge p(w)$
$\lambda w' \exists q.q = [\lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', d, r)] \wedge \neg [\exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w', d, r)]$
$\lambda w \exists p.p = [\lambda w' \exists q.q = [\lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', d, r)] \wedge \neg [\exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w', d, r)]] \wedge p(w)$
$\lambda w \exists p.p = [\lambda w' \exists q.q = [\lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', d, r)] \wedge \neg [\exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w', d, r)]] \wedge [\lambda w' \exists q.q = [\lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', d, r)] \wedge \neg [\exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w', d, r)]](w)$
$\lambda w \exists p.p = [\lambda w' \underline{\exists q.q = [\lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', d, r)]} \wedge \neg [\underline{\exists r.r = [\lambda w'''.N(w''', j)]} \wedge S(w', d, r)]] \wedge \exists q.q = [\lambda w'' \exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w'', d, r)] \wedge \neg [\exists r.r = [\lambda w'''.N(w''', j)] \wedge S(w, d, r)]$

In the final line of the tree in (402), we have 'top-level' occurrences of $\exists p$ and $\exists q$, but the introduction of the discourse referent for the proposition r remains under the scope of $\neg$. Even if we could remove the 'redundant' introductions of q and r under p, underlined—note that this is now a disjoint section, as r is under $\neg$—that would not suffice to get r out.

This is not just a fact about NEG, either. Like NEG, an embedding verb like *say* leaves its 'copied' propositional discourse referent not on the 'top-level' but under the scope of S, so any propositional discourse referents introduced within the scope of the reported proposition will similarly be 'captured'. And while any compositional account of appositive relative clauses would be very dependent on the syntactic account adopted, any account in which the relative clause and the head noun form a constituent (e.g., De Vries 2006) would result in the introduction of the relative clause proposition embedded under the denotation of that constituent DP.[77] That is to say, the compositional approach requires us to interpret the introduction of propositional discourse referents either within one another, or under the scope of operators ($\neg$, S, etc.), as illustrated in (402). This raises tricky questions about what it means to have a discourse referent introduced relative to a world. Or, if the introduction of discourse referents are 'extracted' from under the scope of operators, so that we can turn translations like (400a) into those like (388c), what is the procedure that allows us to do so? And are there any unwanted side-effects of doing so? For the meantime, I sidestep these questions by gesturing at a system which is compositional only at the sentence level. I save the precise formulation of a system which is compositional at the morpheme level for future work.

[77] If the head noun and appositive relative clause form a constituent, and that constituent denotes an individual (with embedded propositional content), then that might result in the introduction of a propositional discourse referent under an ι operator.

4.4.6 The status of a proposition

The translations given here for examples involving sentential negation, embedding verbs, and relative clauses all involved the introduction of multiple propositional discourse referents. Of course, explicitly modeling the introduction of such discourse referents was the goal of this system from the outset. I haven't said anything about the status of these propositional discourse referents, though.

It is clear that not all of the propositions available for anaphoric reference have the same status. For one, as we saw, the proposition denoted by the complement of an embedding verb is not a commitment of the speaker, but can optionally be endorsed or denied by the speaker. And the prejacent of negation is not only not a speaker commitment, but in fact is asserted to be false. So right there we have propositional discourse referents for propositions which a speaker is committed to consider true, for those which a speaker is committed to consider false, and for propositions whose truth a speaker is not committed to in any way.

And while the proposition denoted by the matrix clause of a declarative sentence is asserted to be true, and the prejacent proposition of sentential negation is asserted to be false, not all propositions are conveyed via assertion. While the embedding verbs exemplified here (*say* and *think*) do not, some embedding verbs presuppose the truth of their complement propositions. And as we saw in §3.4.4, those complement propositions are indeed available for anaphoric reference, and they too have a different status. That status might be captured in this system if we were to add a method for marking content as presupposed (e.g., with a δ operator); the system as described thus far does not account for that distinction.

Further, the two propositions introduced in the relative clause example (395a), both of which the speaker is committed to consider true, and neither of which is presupposed,

have different statuses. The proposition denoted by the matrix clause, 'Joyce napped', is the main point of the utterance, while the proposition denoted by the appositive relative clause, 'Joyce won the race', is considered to be backgrounded or somehow less central to the utterance. This has been described and modeled by Potts 2005; AnderBois et al. 2013, among others. This different status has consequences for, among other things, how content is responded to. For example, consider the possible responses by another speaker B in (403).

(403) A: Joyce, who won the race, napped.

a. B: Yes, that's true, but she didn't win the race. She came in second.

b. ?? B: Yes, that's true, but she didn't nap. She did lay down, but she was awake.

The response in (403b), which rejects the matrix clause proposition but endorses the appositive proposition, is considered to be significantly degraded in comparison to the response in (403a), which rejects the appositive proposition but endorses the matrix proposition.

The system as described here does not have the tools to represent this difference: both propositions have associated discourse referents, as we observed in §3.4.5, and that's all that can be said about those propositions on the current account.[78] But these different statuses do merit further discussion, especially as they seem to be related to the behavior of propositional anaphora in particular. For example, note that the responses in (403) make use of propositional anaphors. For this reason, in the next chapter we will take a detailed look at these different statuses and how they intersect and interact with propositional anaphora.

[78]The system also does not pay close attention to the relative order of introduction of propositional discourse referents, as might be relevant in a system which modeled the relative salience of discourse referents via a list, as in PLA or UC. That, too, would be desirable in a future model of propositional anaphora, but is beyond the current scope.

4.5 Conclusion

In this chapter, we considered the question of how to formally model propositional anaphora in discourse. We reviewed a number of existing formal systems, some of which model anaphora and some of which model propositions (by means of propositional variables). For each system, we discussed how these systems might handle the data observed in Chapter 3, and what changes (if any) would be necessary before they could do so. In the process, we identified some qualities that are desirable in a system for modeling propositional anaphora, which comport well with the generalization proposed in Chapter 3 for when propositional discourse referents are introduced. For example, associating the introduction of propositional discourse referents with matrix declarative mood, as in Bittner 2009, 2011; or taking sentential negation to be anaphoric on its prejacent proposition, as in Stone & Hardt 1999.

These qualities were then incorporated into a new proposed formal system in §4.4, with the goal of implementing the generalization from the previous chapter. This system is DPL-like in that it introduces discourse referents via the existential quantifier $\exists$: propositional anaphors are treated as free (propositional) variables, which are bound by $\exists$. In addition to propositional variables and propositional identity, this system introduces lambda binding over world variables. This allows for careful treatment of beliefs and other intensional operators, and would eventually be useful in capturing *de re* and *de dicto* attitudes. In the present proposal, however, it also has the effect of rendering the system static; a fully dynamized version of this system, with a dynamic λ and dynamic binding across sentences, remains for future work.

This proposed system was introduced with a simple declarative example sentence, and then with examples involving sentential negation, embedding verbs, and relative clauses. Each of these structures involve a type of operator which takes a propositional

argument and so—in keeping with the Chapter 3 generalization—involves the introduction of a propositional discourse referent. For each example, we observed how the propositional variable representing this discourse referent is introduced, and how it interacts with other operators in the sentence. This approach afforded us a look into how propositional content is represented, and in the process how integral propositional anaphora is to meaning construction. Not only is sentential negation anaphoric—in that what is negated is the variable associated with the prejacent proposition—, as in Stone & Hardt 1999, but so are embedding verbs: the argument of a verb like *say* isn't directly the logical formula (here, the lambda expression) representing the complement clause proposition, but rather the propositional variable which is associated with that formula. The same is likely true for other operators not presented here, including epistemic modal operators and epistemic adverbials.

Like DPL, the system proposed here is compositional at the sentence level, and not at the morpheme level. The generalization put forward in Chapter 3 identifies the introduction of propositional discourse referents with particular morphemes, namely the operators which take propositional arguments, including the declarative mood. But ultimately, the system proposed here runs into trouble when dealing with multiply-embedded clauses. As discussed in §4.4.5, the introduction of propositional variables ends up 'captured' under the scope of one or more lambdas, in a way which is problematic. As such, the current proposal presents only a sentence level compositionality, just like DPL. The next step improvements on this system, which should include not only fully dynamic $\exists$ and λ operators, but also compositionality down to the morpheme level, will remain for future work.

This system also raises some important questions about the status of a proposition in a discourse, and how it should be represented. As discussed in §4.4.6, the formal system proposed here can model whether a proposition is or isn't available for anaphoric refer-

ence (via the presence or absence of an associated propositional variable) and whether a proposition is or isn't a commitment of the speaker (via whether it is applied to the world of evaluation). This system as presented does not, however, model whether a proposition is presupposed or asserted, even among those propositions which are speaker commitments. This system also doesn't model the discourse status of a proposition, in terms of whether the proposition is the main point of an utterance, in the sense used in the discussion of (403). This discourse status, whose definition is a point of disagreement in the literature, has been argued to have important consequences for the way a proposition is interpreted in a discourse, and so it is worth asking whether a model of propositional anaphora like this should reflect this information. This sort of discourse status, how it is defined and diagnosed, and how it interacts with propositional anaphora, are the topics which will be addressed in the next chapter.

CHAPTER 5

PROPOSITIONAL ANAPHORA AND AT-ISSUENESS

5.1 Introduction

As we noted in the previous chapter, not all propositions mentioned in or conveyed by an utterance have the same status in a discourse. Even among those propositions which are speaker commitments (unlike the prejacents of modals or negation), and which are not presupposed, some propositions are considered to be more central to an utterance in a discourse. This has attracted considerable attention in the literature (e.g., Potts 2005 and much subsequent work), as researchers discuss what it means for a proposition to be "at-issue" in a discourse.

Throughout the literature, a tight linking has been posited between the at-issue status of a given proposition—even though there is ongoing debate about how at-issueness should be defined—and that proposition's availability for anaphora. In particular, the (in)felicity of direct assent/dissent to a proposition is often used as a diagnostic for the at-issue status of that proposition (including for evidentials, e.g., Murray 2010; and appositives, e.g., Tonhauser 2012; Syrett & Koev 2015). For example, the sentence in (404) conveys two propositions of arguably different statuses.

(404) Tivi, who is a cat, enjoys chasing her tail. (Murray 2014: (7))

a. No, she doesn't.

b. # No, she isn't.

The matrix proposition—that Tivi enjoys chasing her tail—is available for direct dissent, as shown in (404a), but the proposition conveyed by the appositive relative clause—that Tivi is a cat—cannot be directly dissented with, as shown in (404b). This has been taken

as evidence that the matrix proposition is at-issue where the appositive proposition is not-at-issue.

This tight linking between at-issueness and anaphoric potential is also reflected in formal representations of discourse which have been posited in the literature. For example, the update semantics of Murray 2009, 2014 has at-issue content and not-at-issue content update the discourse context in different ways, and at-issue content introduces a propositional discourse referent while not-at-issue content does not. A similar notion is implemented in AnderBois et al. 2013 for appositives, where propositional variables only represent at-issue content; not-at-issue content updates the context set without introducing a propositional variable. And in Hunter & Asher's (2016) extension of SDRT, all material which is available for anaphora is necessarily at-issue.

In this chapter, I investigate the interaction between at-issueness and propositional anaphora, and argue that there is no tight link between at-issueness and anaphoric availability—that these two properties of propositions are distinct—at least on one definition of at-issueness. I argue that one of the common diagnostics for at-issueness, the assent/dissent test, is not truly diagnostic of this kind of at-issueness, but is instead sensitive to the anaphoric availability of a proposition. I present data which demonstrate that a proposition's at-issue status alone is not sufficient to determine whether it will be available for anaphoric reference (including but not limited to direct assent/dissent), as well as data which show that a proposition's being available for anaphoric reference cannot be used to diagnose its at-issue status.

In §5.2, I provide some background on at-issueness, with the goal of identifying a diagnostic for at-issueness which does not rely on anaphoric availability. In §5.3, I explain the differing behavior of sentence-medial and sentence-final appositives, which has been implicated in the literature on at-issueness, in the context of our new perspective on at-issueness and anaphoric availability. This behavior supports the choice of diag-

nostic identified in §5.2. Using such a diagnostic, in §5.4 I argue that at-issueness and anaphoric availability are distinct, by illustrating felicitous anaphoric reference to not-at-issue propositions (in §5.4.1) and examples of some at-issue content which cannot be referred to anaphorically, including by direct dissent (in §5.4.2). §5.5 concludes, and discusses what this new perspective means for our theories of at-issueness and anaphora. Some of the content of this chapter is an expansion of work in Snider 2017, in press.

5.2 Diagnosing at-issueness

Content which is at-issue is frequently described as the "main point" of an utterance (Potts 2005; Roberts, Simons, Beaver & Tonhauser 2009, among many others). This notion has been formalized in Simons et al. 2010 as relevance to the current Question Under Discussion (QUD, Roberts 1996). At-issueness has also been described formally as a proposed update to the common ground (Murray 2010, 2014; AnderBois et al. 2013; see also Farkas & Bruce 2010). Hunter & Asher 2016 defines at-issueness structurally, as content which is on the "right frontier" of a discourse structure (as described in Polanyi 1988). For the purposes of this chapter, I'll be using the Simons et al. 2010 definition, because it has associated diagnostics which make testable predictions. We will return to these other notions in §5.5. The Simons et al. 2010 definition is as follows, where $?p$ denotes the question whether or not p:

(405) **Revised[79] definition of at-issueness** (Simons et al. 2010: (26))

a. A proposition p is at-issue iff the speaker intends to address the QUD via $?p$.

b. An intention to address the QUD via $?p$ is **felicitous** only if:

i. $?p$ is relevant[80] to the QUD, and

ii. the speaker can reasonably expect the addressee to recognize this intention.

Using this definition of at-issueness, Tonhauser 2012 lists three features of at-issue content and then lays out six diagnostics for identifying the at-issue status of a sentence implication.

(406) Features of at-issue content: (Tonhauser 2012)

I. At-issue content can be directly assented or dissented with

II. At-issue content addresses the question under discussion (QUD)

III. At-issue content determines the relevant set of alternatives

Feature (406II) hews closest to the Simons et al. 2010 definition in (405): content is (defined as being) at-issue if a speaker intends to use it to address the QUD, so at-issue content addresses the QUD. Feature (406III) is a sort of forward-looking counterpart to (406II). Where (406II) is about the relevance of at-issue content to its prior context, (406III) is about how at-issue content shapes what things count as relevant in subsequent discourse. These two features are of a kind, and the diagnostics associated with them pattern together in a way to be demonstrated shortly. Feature (406I), on the other hand, is further removed

[79] Simons et al. 2010 includes an earlier version of this definition which does not make reference to speaker intention. The differences between the two definitions, discussed in the paper, are immaterial here.

[80] Relevance is defined for assertions (and questions) as entailing (or having an answer which entails) a partial or complete answer to the QUD (Simons et al. 2010: (13)).

from the Simons et al. 2010 definition of at-issueness: at least *a priori*, whether something is available for direct assent/dissent is distinct from whether it addresses the QUD.

In the remainder of this section, I will introduce these two classes of diagnostics and then compare them. The goal here is to identify a diagnostic for at-issueness which doesn't rely on anaphora, so that we can then investigate the relationship between at-issueness and anaphoric potential without accidentally conflating the two.

5.2.1 The *question/answer* tests

The diagnostics that Tonhauser 2012 associates with features (406II) and (406III) look at what content establishes or addresses the QUD. These diagnostics, namely Diagnostics #2 & #3a,b, work by constructing and examining the congruence of question/answer pairs, so they constitute what I'll call the *question/answer* tests.

Diagnostic #2 uses the target sentence (the one whose contents we want to test) as the answer to a question (per (406II)). Diagnostics #3a,b turn the target sentence into a question, and then respond to its contents (per (406III)) with a positive/negative answer and a follow-up: either a "positive continuation" (e.g., *Yes, she is*) for #3a, or an "adversative continuation" (e.g., *Yes, but she is*) for #3b. The idea here is that because at-issue content addresses and establishes the QUD, content which fails to address the QUD or which fails to establish a QUD must be not-at-issue.[81]

To illustrate the question/answer tests, Tonhauser's (2012) Diagnostic #2 is given in (407) and exemplified in (408–409), and Diagnostic #3a is given in (410) and exemplified in (411). To demonstrate these tests, I'll be using sentences with appositives, which are thought to convey content which is in some way less central to the utterance (e.g., Potts 2005; Tonhauser 2012; AnderBois et al. 2013; Murray 2014).

[81] An explicit question, like those used in all three question/answer tests, might not override an overarching Domain Goal, but it is enough to establish an immediate Discourse Goal (Roberts 1996).

(407) **Diagnostic #2:** Create a discourse in which speaker A utters a question with meaning $?\vec{x}.m$ and an addressee B utters answers that convey $\exists\vec{x}.m(\vec{x})$ as at-issue content and not-at-issue content, respectively. Ask the consultant about the acceptability of these answers to the question. (Tonhauser 2012: (16))

(408) Who did Food Network interview?

a. Pauline, who is Margaret's cousin, was interviewed by Food Network.

(409) Who is Margaret's cousin?

a. # Pauline, who is Margaret's cousin, was interviewed by Food Network.

The same sentence is used to answer the different explicit questions in (408) and (409). The response in (409a) fails to felicitously address the QUD, even though the content conveyed by the appositive entails an answer to the question in (409), so the appositive content must be not-at-issue. (If it were at-issue, it would be able to address the QUD.) The felicity of the response in (408a), meanwhile, is consistent with the matrix clause content being at-issue.

(410) **Diagnostic #3a:** Let *S* be a sentence that gives rise to hypothesized at-issue content *m* and hypothesized not-at-issue content *n*. Form a polar question *Q* from *S*. Create a discourse where interlocutor A utters *Q* and addressee B's positive (negative) response is followed by utterances of simple sentences that convey *m* or *n* ($\neg m$ or $\neg n$) as at-issue content. Ask the consultant about the acceptability of B's answers. (Tonhauser 2012: (19))

(411) Was Pauline, who is Margaret's cousin, interviewed by Food Network?

a. Yes, she was.

b. No, she wasn't.

c. # Yes, she's Margaret's cousin / she is.

d. # No, she's not Margaret's cousin / she's not / she isn't.

The (c) and (d) responses of (411), which respond to the content conveyed by the question's appositive clause, are infelicitous, which is evidence that that appositive content is not-at-issue. (If the question's appositive clause content were at-issue, it would establish the very alternatives that the (c) and (d) responses convey.) The felicity of the (a) and (b) responses, which respond to the question's matrix clause content, is consistent with that matrix clause content being at-issue.

The question/answer tests look at the way at-issue content interacts with the QUD, both in terms of responding to an existing QUD (as in Diagnostic #2) and in setting up a QUD to be addressed (as in Diagnostics #3a,b).

5.2.2 The *direct assent/dissent* tests

The other three diagnostics from Tonhauser 2012 (Diagnostics #1a–c) trade on feature (406I), that "at-issue content can be directly assented or dissented with". These tests rely on identifying the content which is targeted by a statement of direct assent/dissent.

For Diagnostic #1a, a sentence which conveys multiple contents is directly assented/dissented with, and consultants are asked what is being assented/dissented with. In Diagnostics #1b,c, this judgment is less overt, as consultants are asked only to judge the felicity of discourses with direct assent/dissent. In Diagnostic #1b, assent/dissent is followed up with a "positive continuation" (e.g., *Yes, that's true, he did*), and in Diagnostic #1c it is followed up with an "adversative continuation" (e.g., *Yes, that's true, but he didn't*).

Overall, the idea is that because at-issue content can be directly assented/dissented with, content which cannot be assented/dissented with in this way must be not-at-issue (because if it were at-issue, it would be able to be assented/dissented with).

Though feature (406I) and its associated diagnostics are described as dealing with both assent and dissent, the two do not behave identically. There are cases where dissent is felicitous but assent is not.

(412) Bill has spoken to Mary, who is Martin's best friend.

a. No, Mary is not Martin's best friend / she isn't.

b. ? Yes, Mary is Martin's best friend / she is.

Indeed, where assent seems to be the 'default' result of an unopposed assertion, dissent requires an overt action. Overtly agreeing, then, is often marked. As such, I will focus for the remainder of this paper only on direct dissent, and refer to this as the *direct dissent* test.

For an example of the direct dissent test in action, Tonhauser's (2012) Diagnostic #1b, given in (413), is demonstrated in (414). As Tonhauser 2012: 244 points out, "This diagnostic has been applied in e.g. Faller (2002), von Fintel and Gillies (2007), Matthewson et al. (2007) and Murray (2010)."[82]

(413) **Diagnostic #1b:** Create a discourse in which interlocutor A utters the target utterance and in which addressee B responds to A's utterance with a simple assent(dissent) utterance followed by an utterance that conveys (the negation of) the hypothesized at-issue content, or where B responds with a simple assent (dissent) utterance followed by an utterance that conveys (the negation of) a hypothesized

[82]Faller 2002, Matthewson, Davis & Rullmann 2007, and von Fintel & Gillies 2007 use the direst dissent test to determine whether (evidential or modal) content contributes to the truth conditions of a sentence; they don't mention at-issueness as such. Tonhauser 2012 understands these uses as in fact diagnosing Simons et al. 2010 at-issueness.

not-at-issue content. Ask the consultant about the acceptability of B's responses.

(Tonhauser 2012: (10))

For the reason discussed above, I exemplify this diagnostic with only the direct dissent variation.

(414) Pauline, who is Margaret's cousin, was interviewed by Food Network.

a. No, she wasn't interviewed by them.

b. #/?? No, she isn't Margaret's cousin.

The questionable felicity of (414b), which targets the appositive content of (414), is taken as evidence that this appositive content is not-at-issue: if it were at-issue, it should have been perfectly felicitous to directly dissent with. The felicity of (414a), meanwhile, is consistent with the matrix clause content being at-issue.

The direct dissent test looks at the ability of content to be directly rejected, taking at-issue content to be always available for direct dissent. Tonhauser 2012 makes no claims about the ability of not-at-issue content to be directly dissented with, but if all at-issue content can be directly dissented with, then any content which cannot must be not-at-issue.

5.2.3 Comparing the *question/answer* and *direct dissent* tests

The question/answer and direct dissent tests align in many cases. For example, the above examples all point to the content conveyed by appositive clauses being not-at-issue. There are differences between these classes, though, which I will argue make them crucially different. Tonhauser 2012 notes that the six diagnostics presented don't always behave identically, but attributes those differences to the type of implication being tested: "not all diagnostics are conclusive for all projective contents" (p. 251). At the

end of the day, though, Tonhauser asserts that they are all indeed testing for at-issueness: "they are all useful to diagnose (not-)at-issueness with at least one kind of content" (p. 252). I'll argue that where the question/answer tests are indeed useful for diagnosing (not-)at-issueness, the direct dissent tests are mediated by the anaphoric availability of a propositional antecedent, and so are in fact testing not for at-issueness but for anaphoric availability.

The anaphoric nature of the direct dissent tests is apparent in their reliance on propositional anaphors. The mechanisms that underlie direct assent/dissent are themselves anaphoric: response particles, which have been argued to be anaphoric (Murray 2010; Krifka 2013; Roelofsen & Farkas 2015), and other propositional anaphors like *that* (e.g., in *That's not true*). The direct dissent tests explicitly rely upon the anaphoric nature of the response particles, identifying the antecedent content (Diagnostic #1a) and looking for inconsistencies between the antecedent content and explicit follow-up material (Diagnostics #1b,c).

In contrast, the question/answer tests do not rely on the use of propositional anaphors. This difference is easy to miss in the presentation of the diagnostics in Tonhauser 2012, where two of the three question/answer tests are demonstrated with examples that make use of response particles. The Guaraní follow-ups begin with *heẽ* 'yes' or *nahániri* 'no', and if these response particles work like those of other languages (i.e., those discussed in Krifka 2013; Roelofsen & Farkas 2015), then they're likely best analyzed as propositional anaphors themselves. But this illustration with explicit anaphors is only incidental for the question/answer test: the examples shown in (411) return the same

results even without the use of response particles.

(415) Was Pauline, who is Margaret's cousin, interviewed by Food Network?

a. She was.

b. She wasn't.

c. # She's Margaret's cousin / she is.

d. # She's not Margaret's cousin / she's not / she isn't.[83]

The responses in (415a) and (415b), which morphologically agree with the tense of the question's matrix clause, are felicitous answers to the question, suggesting that the question's matrix clause content establishes a QUD to be addressed (and so is at-issue). The responses in (415c) and (415d), meanwhile, which agree with the question's appositive, are infelicitous, suggesting that the question's appositive content is not-at-issue, as it does not establish a QUD. This is the same behavior as we saw in (411), unchanged despite the removal of the response particles.

The question/answer tests return the same results regardless of the presence/absence of anaphors (response particles) because their use of them is only incidental. In contrast, the direct dissent tests rely on explicit anaphors by design; an anaphor-less equivalent to the direct dissent test in (414) ceases to be the same diagnostic, as demonstrated in (416).

(416) Pauline, who is Margaret's cousin, was interviewed by Food Network.

a. She wasn't interviewed by them.

b. She isn't Margaret's cousin.

The responses in (416) are both understood to be corrections, and there is no apparent dif-

[83] To the extent that *She's not Margaret's cousin* is a felicitous discourse move, it is not a response to the question posed, but rather a correction. It does not address the QUD. Note, in contrast, that *She's not* and *She isn't* don't have the same potential to be felicitous in this context, perhaps because they are too elliptical to be a useful correction.

ference in acceptability between a correction of the matrix clause content and a correction of the appositive clause content. While there is still work to be done in precisely defining what "direct dissent" is, the presence of these response particles is not incidental. Rather, the direct dissent tests critically rely on them, and cease to be the same tests without such anaphors.

The direct dissent tests are mediated by the anaphoric availability of a propositional antecedent, and thus do not in fact diagnose at-issueness, at least not directly. It could only be taken to diagnose at-issueness if at-issueness and anaphoric potential were one and the same: if all and only at-issue content were available for anaphoric reference. In section §5.4 I will show that this is not the case. I'll use the question/answer test (Diagnostic #2) to establish the at-issue status of content independently of its anaphoric availability. I won't use the anaphora-based direct dissent tests, because as I will demonstrate, one can directly dissent felicitously to both at-issue and not-at-issue content, and there is at-issue content which cannot be directly dissented with.

First, however, I will address a potential objection to the presentation of the data we have seen thus far, namely the difference between sentence-medial and -final appositives. I'll argue that their behavior in fact provides further support for my characterization of the direct dissent test as anaphoric and thus less reliable for diagnosing Simons et al. 2010 at-issueness.

5.3 Medial & final appositives

All of the appositives diagnosed as not-at-issue in Tonhauser 2012, and here in the previous section, were sentence-medial, but it has been noted that the ability of an appositive to be targeted by direct assent/dissent is sensitive to the position of the appositive clause in a sentence (AnderBois et al. 2013; Syrett & Koev 2015). In this section, I explain this sensitivity as a consequence of the anaphoric nature of the direct dissent test, and demon-

strate that the question/answer tests do not show the same behavior. This is further evidence for my claim in §5.2 that the question/answer tests truly diagnose at-issueness, in contrast to the direct dissent tests, which diagnose only anaphoric availability.

AnderBois et al. 2013 gives (417b) as an example of felicitous direct dissent to a sentence-final appositive.

(417) a. He told her about Luke, who loved to have his picture taken.
b. No, he didn't like that at all.
c. No, he told her about Noah. (AnderBois et al. 2013: (52))

This was tested experimentally in Syrett & Koev 2015, which examined participants' willingness to accept direct dissent to appositives in medial and final positions (for both nominal and clausal appositives). Syrett & Koev 2015 confirmed the intuition that sentence-final appositives are more acceptable targets for direct dissent than medial appositives.

Syrett & Koev 2015 takes the existence of felicitous dissent to appositives, both medial and final, as evidence for the "shifting at-issue status" of appositives. "[W]e believe we have reason to think that these appositives may take on at-issue status, provided we assume that being the target of a direct rejection is one of the main diagnostics for being at issue. (See, for example, Tonhauser 2012.)" (p. 551–552). This analysis explicitly presumes that direct rejection (that is, direct dissent) is evidence for at-issue status.

Syrett & Koev 2015 comes to this conclusion because it relies exclusively on the direct dissent tests as a diagnostic for at-issueness. As discussed in §5.2, the direct dissent tests rely on anaphoric availability, so they can be misleading as to the interaction between at-issueness and anaphoric potential. To make this point even clearer, we can observe the anaphoric nature of the direct dissent tests in their behavior around medial and final appositives.

The direct dissent tests, demonstrated in §5.2 only with medial appositives, are sensitive to the position of an appositive: compare the direct dissent test with a medial appositive in (414), repeated here, to a final appositive, as in (418).

(414) Pauline, who is Margaret's cousin, was interviewed by Food Network.

a. No, she wasn't interviewed by them.

b. #/?? No, she isn't Margaret's cousin.

(418) Food Network interviewed Pauline, who is Margaret's cousin.

a. No, they didn't interview her.

b. ? No, she isn't Margaret's cousin.

The response in (418b) is significantly less marked than that of (414b). This is the same effect noticed by AnderBois et al. (2013) and confirmed by Syrett & Koev (2015). We can explain this behavior if we consider the anaphoric nature of the direct dissent tests. Anaphora resolution is sensitive to recency, among other things (Ariel 1988 and references therein), so it shouldn't be surprising that the direct dissent tests, which crucially rely on anaphora, return different results for more recent material (here, sentence-final appositives).

The question/answer tests, in contrast, show unchanging behavior for both medial and final appositives. Diagnostic #2 identifies matrix content as at-issue (in (408)) and

appositive content as not-at-issue (in (409)), regardless of the position of the appositive:

(408) Who did Food Network interview?

a. Pauline, who is Margaret's cousin, was interviewed by Food Network.

b. Food Network interviewed Pauline, who is Margaret's cousin.

(409) Who is Margaret's cousin?

a. # Pauline, who is Margaret's cousin, was interviewed by Food Network.

b. # Food Network interviewed Pauline, who is Margaret's cousin.

Diagnostic #3a is similarly unaffected by the position of the appositive. The same behavior we saw with a medal appositive, in (411) repeated here, can be observed with a final appositive, as in (419).

(411) Was Pauline, who is Margaret's cousin, interviewed by Food Network?

a. Yes, she was.

b. No, she wasn't.

c. # Yes, she's Margaret's cousin / she is.

d. # No, she's not Margaret's cousin / she's not / she isn't.

(419) Did Food Network interview Pauline, who is Margaret's cousin?

a. Yes, they did.

b. No, they didn't.

c. # Yes, she's Margaret's cousin / she is.

d. # No, she's not Margaret's cousin / she's not / she isn't.

The question/answer tests show the same results for all appositives, regardless of their position in the sentence, and do not appear to be sensitive to recency. They are sensi-

tive to discourse structure—the QUD—but not the sentential position of the material that establishes or addresses that QUD.

The direct dissent tests show differing behavior based on the position of the appositive in the sentence, as they are sensitive to recency. This supports the notion that the direct dissent tests are in fact not diagnosing at-issueness, but the anaphoric availability of a proposition. The QUD-based question/answer tests, in contrast, are not sensitive to the position of an appositive in a sentence. These diagnostics illustrate that neither medial nor final appositives can address or establish a QUD, and are thus not-at-issue on the Simons et al. 2010 definition.

Syrett & Koev 2015 acknowledges the existence of these QUD-based diagnostics, but argues that appositives in fact can address the QUD, discussing two examples. I'll now argue that neither example offers conclusive evidence that appositives can address the QUD, and that the behavior observed here shows both medial and final appositives to be not-at-issue. Thus, I argue, the question/answer tests are reliable diagnostics for at-issueness in a way that the direct dissent tests are not.

First, Syrett & Koev 2015 discusses an example where an appositive alone does not address the QUD but nevertheless "helps to provide an answer to either of the two QUDs preceding it" (586). Those explicit questions, though, are *why* interrogatives, in contrast to the polar and *wh-* interrogatives used in Tonhauser 2012 (and here). *Why* questions are crucially different from these other questions in that they seek explanations. Because they seek explanations, such questions have no single comprehensive answer: any answer given is defeasible[84] or can be considered insufficiently precise, and additional contextual information can always contribute to an explanation (see discussion in Bjorndahl

[84]For example, even a straightforward answer to a *why* interrogative is defeasible.

(xiv) Q: Why are these flowers on the table?
A: Edgar put them there this morning.
A′: Edgar put them there this morning. But then at noon, he moved them to the bookshelf. Vanessa moved them back to the table after Edgar left. So, Vanessa is why those flowers are on the table.

& Snider 2016). The appositive might contribute information which bolsters an explanation, supporting the matrix clause's answer to the QUD, but that alone does not constitute addressing the QUD. If the matrix clause does not address the QUD, then an appositive alone cannot be taken to address the QUD, even in a *why* question, as in (420).[85]

(420) Why did Sophie perform a piece by Mozart?

a. Sophie, who received the longest ovation, adores Mozart.

b. # Sophie, who adores Mozart, received the longest ovation.

c. # The longest ovation went to Sophie, who adores Mozart.

A sentence-final appositive, as in (420c), fares no better at addressing a *why* QUD than a medial one, as in (420b).

Syrett & Koev 2015: 587 further points to an example where an appositive appears to "address one part of a coordinated QUD", inspired by an example from Koev 2013.[86]

(421) Q: Who did you see at the potluck and what dish did they bring?

A: I saw Renée, who brought an artichoke dip. (Syrett & Koev 2015: (47))

But the concept of a "coordinated QUD" is novel: Roberts 1996 describes no such structure, instead describing sequences of "relevant sub-questions to some super-question" as

[85]The only way to get a felicitous reading for (420b) is if one understands Sophie to have chosen her piece with the intention of getting the longest ovation of the night, along with the assumption that she knew Mozart to be a crowd favorite. On this reading, of course, it is the main clause which addresses the QUD, supported by a body of contextual knowledge; the appositive still does not address the QUD.

[86]Koev 2013 also points to (xv) from Simons et al. 2010 as evidence that appositives can address the QUD.

(xv) Q: Who's coming to the dinner tonight?

A: Well, I haven't talked to Charles, who probably won't be able to come, but I did talk to Sally, who is coming. (Simons et al. 2010: (27))

Simons et al. 2010, however, doesn't describe this as a case of the appositive addressing the QUD. They describe the example as follows: "Rather than directly answering the overt question, A instead answers the question of who she has talked to about the dinner" in a way that "includes answers to the overt question" (324). It includes answers to, but it does not itself answer the explicit question—see the discussion of (421).

an "enumeration, suggesting a plan for how to attack the super-question", and says that one "can only address such sub-questions one at a time" (5). The response in (421A) thus addresses the first sub-question—as it must, because the second requires an answer to the first—and not both at once. Rather than thinking of the appositive in (421A) as addressing the second sub-question, we should consider it to merely add extra information to the answer that addresses the first, in just the same way that the appositive in (421A′) does.

(421) A′: I saw Renée, who is a doctor. (She brought an artichoke dip.)

A subsequent sentence could address the second sub-question, as in (421A′), but the response in (421A) only addresses the first sub-question about who the addressee met. The appositive in (421A) *does* entail an answer to the second sub-question, but it is not relevant to the current QUD (the first sub-question), and so it is not at-issue on the Simons et al. 2010 definition.

We have seen, then, that the question/answer tests return the same results for both medial and final appositives; being QUD-based, they are indifferent to the sentence position of an appositive. Appositives cannot address the QUD, even in *why* questions, and so are not-at-issue. The direct dissent tests, in contrast, are sensitive to recency, because they are anaphora-based and so do not reliably diagnose at-issue status. In the next section, then, we will make use of the question/answer tests—and not the direct dissent tests—to establish the at-issue status of propositions whose anaphoric availability we want to test.

5.4 Distinguishing at-issueness from anaphoric availability

Having identified the question/answer tests as reliable diagnostics for the at-issue status of a proposition, we can now carefully observe the interaction between the at-issue status of a proposition and its availability for subsequent anaphoric reference. In this section, I'll argue that the two are distinct: at-issue status is neither a necessary nor

sufficient condition for the anaphoric availability of a proposition.

5.4.1 At-issueness is not necessary for anaphora

In this section, I'll present data which illustrate felicitous anaphoric reference to not-at-issue content. This demonstrates that a proposition's being available for anaphoric reference cannot be used to diagnose its at-issue status. In other words, at-issue status is not necessary for anaphoric availability, either for direct rejection or for anaphora broadly. This calls into question the tight linking between at-issueness and anaphoric potential, as well as the explicit assumption made in Syrett & Koev 2015 that being targeted by direct rejection implies at-issue status.

As discussed in the previous section, I'll be using a question/answer test to diagnose content as being at-issue or not-at-issue. The novel examples that follow will have an explicit question establishing the QUD and some at-issue content which addresses that QUD, both presented in boldface for ease of identification. Propositional anaphors (including but not limited to response particles) will be presented in italics, with their antecedents underlined.

First, let's look at an appositive, which as we've already seen is typically taken to convey not-at-issue content.

(422) [Mark is a high school teacher. His parents come to visit during a school assembly. His father is looking around the auditorium, curious about Mark's students.]

Dad: **Where are Mark's students sitting?**

Mom: **Lisa**, <u>who is Mark's favorite</u>, **is sitting in the front row**.
He told me *that* in confidence, though, so don't tell anyone.

The QUD in (422) is about where Mark's students are sitting, and is addressed by the

matrix clause content of the response: Lisa is sitting in the front row. The content conveyed by the appositive, that Lisa is Mark's favorite, does not address the QUD, and so is not-at-issue by the question/answer test (and so is not in boldface). The anaphor *that* in (422) most plausibly refers to the content conveyed by the appositive, even though it is not-at-issue: the context of (422) makes it very odd for where someone is sitting—presumably public knowledge—to be something Mark would say in confidence, making the matrix content an ill-fitting referent for *that* to pick up. In contrast, that a teacher has a favorite student is precisely the sort of thing a teacher might want to keep secret, so the appositive content is a fitting antecedent. The matrix proposition has an associated discourse referent, and so is a competitor as potential antecedent, but the context makes the matrix proposition an ill-fitting antecedent, leaving instead the more plausible appositive proposition. So here we have felicitous anaphoric reference to a truly not-at-issue proposition.

(422) shows us a propositional anaphor (*that*) referring to a not-at-issue proposition, but not direct dissent. On its own, (422) suggests that felicitous direct dissent of appositive content, such as was demonstrated by Syrett & Koev 2015, needn't invoke a "shifting" at-issue status: if this sort of not-at-issue content is available for anaphoric reference by means other than direct dissent, then why posit a change in status when it is also available for direct dissent? It may be the case that in fact direct dissent is more restricted than propositional anaphora generally (at least in English[87]). As we'll see in a moment, though, there is also felicitous direct dissent to not-at-issue content.

The anaphoric availability of not-at-issue content is not a feature only of appositive content; we can also see parallel behavior in speech/attitude reports. Such reports convey multiple propositions which can be at-issue in a given context (Simons 2007, see also Hunter 2016). For any given report, the matrix clause content which describes the report-

[87]Krifka 2013 accounts for the more restricted behavior of *yes* compared to German *ja* by positing a syntactic difference, that the latter is at the level of TP while the former is an ActP.

ing event may be at-issue, or the embedded clause content which conveys the report may be at-issue, depending on context. For example, the B responses in (423) and (424) are the same, modulo pronoun resolution and ellipsis, but they differ in terms of which content is at-issue.

(423) A: Who was Louise with last night?
B: Henry thinks she was with Bill. (Simons 2007: (2))

(424) A: What is bothering Henry?
B: He thinks Louise was with Bill last night. (Simons 2007: (3))

In (423), the QUD is about Louise and who she was with. This is addressed by the embedded clause content of B's response; the matrix content about Henry only provides the source of the relevant at-issue information, and is itself not-at-issue. Hunter 2016 calls this use a "discourse parenthetical report", as the matrix clause serves to parenthetically supply the attribution of the embedded report. In contrast, the context of (424) makes the QUD about Henry and his state of mind. This is addressed by the matrix clause content of B's response, so it's what's at-issue. The reported content itself is not-at-issue.

In the context of an explicit question which makes the at-issue content clear (that is, using a question/answer test), we can see felicitous anaphoric reference to a not-at-issue proposition in a speech report, as in (425):

(425) Q: **Who was at the party?**
A: Kevin said **Meghan was there**. Erin told me *that*.

In the context of (425), it is the embedded clause content of A's response which is at-issue: the QUD is about who was at the party, and the embedded clause is what addresses it. The matrix clause content attributes the source of this report, but is itself not-at-issue. And yet, a very natural interpretation of (425) is for Erin to have spoken about Kevin, i.e.,

for the anaphor *that* to target the not-at-issue matrix clause content.[88]

As in (422), the example in (425) uses a propositional anaphor in a single speaker follow-up. We can also see direct assent/dissent to not-at-issue content in a parallel speech report example:

(426) A: **Who was at the party last night?**

B: Gabrielle said **Polly was there**.

a. C: *Yes, that*'s true, but she's mistaken. **Polly was at the movies**.

b. C: *No, that*'s not true, she said $[\text{PAULIE}]_F$ was there; you must have misheard her.

Just like in (425), the QUD in (426) is addressed by the embedded clause content of B's response, both in boldface. The matrix clause content of B's response introduces the source of the report, but doesn't address the QUD, and so is not-at-issue. Nevertheless, this not-at-issue matrix clause content is available for direct assent in (426a) or direct dissent in (426b). In (426a), the anaphors *yes* and *that* refer to the matrix clause content of B's response: C affirms the reporting but then goes on to deny the content of the report itself. (426a) addresses the QUD only in the final clause: Polly was at the movies, and thus was not at the party. In (426b) as well, the anaphors *no* and *that* refer to the matrix clause content of B's response, here denying the reporting itself (explained as a mishearing). (426b) doesn't itself address the QUD, in that it doesn't entail even a partial answer to *Who was at the party?* nor does it preclude Polly from having in fact been at the party (independently of Gabrielle's report). It does serve to prevent perhaps-false information

[88](425) is at least very marked, if not infelicitous, as a way to report that Erin said something about Meghan directly. Contrast (425) with (xvi):

(xvi) A: **Who was at the party?**
B: Kevin said **Meghan was there**. Erin told me *that*, too.

The embedded clause content is still available for anaphoric reference, but without the addition of *too*, the anaphor in (425) more naturally is interpreted as referring to the matrix clause content.

from being added to the common ground, though, if A would otherwise have accepted B's assertion as truthful.

The responses in (426) show felicitous direct assent/dissent to not-at-issue content, without a change in topic or other indication of a shift in QUD (and thus what is at-issue). Together with (422) and (425), we have evidence of licit anaphoric reference to not-at-issue propositions. This shows us, first, that at-issueness is not necessary for a proposition to be available for anaphoric reference, and second, that being targeted by a propositional anaphor, even in direct dissent, is not evidence for a proposition's at-issueness, contra the assumption of Syrett & Koev 2015.

5.4.2 At-issueness is not sufficient for anaphora

In this section, I'll present data on at-issue contents which systematically fail to be available for anaphoric reference. This illustrates that given only knowledge about the at-issue status of a proposition, we can't predict whether it will be available for anaphora. In other words, at-issue status is not sufficient for anaphoric availability, either for direct dissent or for anaphora broadly. This calls into question not only the tight linking of at-issueness and anaphoric potential in the literature, but also feature (406I) from Tonhauser 2012.

Roberts et al. 2009: 5 tells us that "at-issue content may include non-conventional content as well, e.g. conversational implicatures which arise as a result of the utterance in context", as exemplified by the conversational implicature in (427), the example originally from Kadmon 2001.

(427) A: I have to pay this bill.
B: The customer accounts office isnt open today. (Roberts et al. 2009: (9))

"[S]peaker B intends to convey (ii) that A will not be able to pay her bill (or at least not in the standard way). The second implication, a Relevance implicature, is what is directly at-issue in the utterance: it is what is intended by the speaker to help resolve the implicit question raised by A's utterance." (Roberts et al. 2009: 5).

The same is true of presuppositions, as "a presupposition. . . can have main point status" (Simons 2005: 340), exemplified in (428).

(428) Ann: The new guy is very attractive.
Bud: Yes, and his wife is lovely too. (Simons 2005: (10))

Simons 2005: 340 tell us that "the main point of Buds utterance is to inform Ann that the new guy has a wife". It of course also conveys that his wife is lovely, but "another of the communicated propositions, namely that the new guy has a wife, is more relevant for Ann than the fact that the wife is lovely" (p. 341) and Ann recognizes Bud's intention for her to pick this up, as reflected in the Simons et al. 2010 definition of at-issueness in (405).

In this section, I'll show that these sorts of at-issue propositions systematically fail to be available for anaphoric reference. Just like in the previous section, I'll use a question/answer test to clarify the at-issue status of the various propositions floating around in each example. First, let's look at a presupposition.

(429) Q: **Does Vicky have any siblings?**
A: Her brother is a chef, just like me. Her mom told me *that*.
✓that he's a chef
that **he exists**

In (429), the explicit QUD is about whether Vicky has any siblings. This QUD is addressed via the existence presupposition triggered by the DP *her brother*: Vicky's brother exists, therefore she has at least one sibling. That he is a chef, the main clause content, does not

address the QUD; it is only the existence presupposition that is at-issue. The anaphor *that*, however, can't be interpreted as referring to the at-issue proposition that Vicky's brother exists. It can only be understood as referring to the proposition that he's a chef. If Vicky's mom had in fact only told A about his existence, and not his profession, (429) would not be a felicitous way to report that. The at-issue status of the existence presupposition is not enough to make it available for anaphoric reference. This is in keeping with our observation in §3.2.3 that possessives don't introduce propositional discourse referents. This existence proposition's being at-issue does not change that behavior.

We can see the same with a non-presuppositional entailment, as in (430).

(430) [Kim and Jessie are high school students. Kim's mom asks Jessie's:]
Q: Where was Kim last night? **Was she at the party?**
A: The whole class was there! Jessie told me *that*.
✓that the whole class was at the party
that **Kim was at the party**

The explicit QUD in (430) is about whether Kim was at the party, but the response given is about the whole class. The QUD is only addressed by an entailment of the answer: if the whole class was there, then Kim must have been there. This entailed proposition is what addresses the QUD and so is at-issue. The anaphor *that* can't be taken to refer to the proposition about Kim, however. The only possible reading of (430) is for Jessie to have told her mom that the entire class was at the party. The proposition that Kim was at the party, even though it is at-issue, is not an available antecedent for anaphoric reference.

We can see the same pattern with a conversational implicature, as in (431).

(431) Q: **Will Gretchen be able to make the meeting?**

A: There's a pile-up on I-287. Alexa told me *that*.

✓that there is a pile-up on I-287

that **Gretchen won't make the meeting**

The explicit QUD in (431) is about Gretchen, but the response given is about a traffic accident. The QUD is only addressed via conversational implicature, in particular a Relevance implicature: the only way we can take A's response as relevant is if the traffic will affect Gretchen's attendance at the meeting. Given world knowledge and some other assumptions, we take it that the traffic does bear on this question: presumably Gretchen would normally take I-287 to get to the meeting, and so now will be unable to attend or will be delayed. In other words, A's response conveys, via conversational implicature, the proposition that Gretchen won't make the meeting. It's this proposition which addresses the QUD, and so it's this proposition which is at-issue in the context of (431).

Despite being at-issue, the proposition that Gretchen won't make the meeting (on time) is not an available antecedent for the anaphor *that*. The only available interpretation of (431) has Alexa reporting on the traffic accident, whether or not she knows about Gretchen or the meeting. If Alexa had told A only about Gretchen's attendance without knowing the cause of the delay, (431) is not a felicitous way to report that. So here, too, we have an at-issue proposition which is unavailable for anaphoric reference.

A version of (431) which involves direct dissent shows us the same unavailability:

(432) Q: **Will Gretchen be able to make the meeting?**

A: There's a pile-up on I-287.

B: #*No, that*'s not true! She'll be there, she took the subway today!

✓that there is a pile-up on I-287

that **Gretchen won't make the meeting**

This variant (432) has the same QUD, the same response, and the same Relevance implicature as (431). Here B attempts to directly reject the at-issue proposition that Gretchen won't make the meeting, offering in a follow-up a reason to reject the Relevance implicature: she took the subway, so road traffic won't affect her travel. Nonetheless, the anaphors *no* and *that* here obligatorily target the proposition that there's a pile-up; they cannot refer to the at-issue proposition that Gretchen won't make the meeting. According to Tonhauser 2012, at-issue content can be directly dissented with, but (432) shows us that this is not the case for (at least some) at-issue conversational implicatures.

Parallel examples to (429) and (430) that include direct rejections of entailed content are hard to construct in a way that makes them demonstrative.

(433) [Kim and Jessie are high school students. Kim's mom asks Jessie's:]
Q: Where was Kim last night? **Was she at the party?**
A: The whole class was there!
B: #*That*'s not true! Kim was the library all night!

B's direct dissent in (433) denies the claim that Kim was at the party, but it's difficult to determine whether this dissent *targets* that at-issue proposition, or whether it in fact still targets the asserted proposition about the whole class. After all, knowing that Kim was at the library is a reason to deny the claim that the whole class was at the party. My intuition is that indeed this direct dissent can only target the content that the entire class was there, bearing on the at-issue content only indirectly, but this is hard to demonstrate conclusively.

Nevertheless, the data in (429)–(431) are evidence that not all at-issue content can be targeted by propositional anaphors. And at least in the case of conversational implicature, (432) shows us an example where at-issue content cannot be directly dissented with. It is not the case, then, that all content which is at-issue on the Simons et al. 2010 definition is

available for direct dissent specifically (contra Tonhauser 2012), or for anaphoric reference more broadly.

5.5 Discussion

Despite the tight linking between at-issueness and anaphoric availability presumed in the literature, the data presented here show that the two notions are independent of one another, and must be distinguished. Of the diagnostics presented in Tonhauser 2012, only the question/answer tests, which tap into what content establishes and addresses the QUD, diagnose at-issueness as defined by Simons et al. 2010. The direct dissent tests, which are moderated by the availability of anaphoric antecedents, do not diagnose at-issueness at all, but rather anaphoric availability.

If we're interested in the question of what diagnoses at-issueness, then the data presented here demonstrate that a proposition's being anaphorically available is neither necessary nor sufficient to determine its at-issue status. The data in §5.4.2 show that felicitous anaphora is not necessary for determining a proposition as being at-issue, as we can see the systematic infelicity of anaphoric reference to content which is nevertheless at-issue. The data in §5.4.1 show us that anaphoric availability is not sufficient, either, as we have felicitous anaphoric reference to a proposition, where that proposition is nonetheless not at-issue.

Alternatively, if we're interested in the question of what determines the anaphoric potential of a proposition, then the data presented here demonstrate that a proposition's being at-issue is neither necessary nor sufficient to determine its anaphoric potential. The data in §5.4.1 show us that at-issueness is not necessary, as we have felicitous anaphora (including direct dissent) to not-at-issue propositions. The data in §5.4.2 show us that at-issueness is not sufficient, as we have at-issue propositions which are systematically unavailable for anaphoric reference, direct dissent or otherwise. The availability of a

proposition discourse referent is not sensitive to its at-issue status.

With this insight in hand, there are different directions we could go with our theory of at-issueness. If we want to pursue a Simons et al. 2010 notion of at-issueness, then we must decouple it from anaphoric potential. This means that we cannot rely on the direct assent/dissent tests as a diagnostic for at-issue status, as they behave differently from the QUD-based diagnostics.

Alternatively, this observation might lead one to move away from the Simons et al. 2010 definition entirely. If we want to model at-issueness using a discourse update system as in Murray 2010, 2014 or AnderBois et al. 2013, then we need to be careful to ensure that the mechanisms distinguishing at-issue and not-at-issue content are distinct from those that determine the availability of propositional anaphora. These systems are compatible with such changes; as Murray 2014: 8 puts it, the information conveyed by a not-at-issue proposition "is still present [and] recoverable". The Murray 2010, 2014 model applied to English, then, would simply introduce propositional discourse referents for both at-issue and not-at-issue content, but retain the different update procedure of each. Similarly, AnderBois et al. 2013 could be easily modified to associate a propositional variable with not-at-issue content, even while the update procedures are distinct.

Or, we might prefer a system like that of Hunter & Asher 2016, which proposes a discourse based definition of at-issueness using SDRT (Asher 1993; Asher & Lascarides 2003). On this account, at-issueness and anaphoric potential are indeed closely linked, but in a way that isn't at odds with the data discussed here, because they use an entirely different notion of at-issueness. As defined in Hunter & Asher 2016: 1036, "content is at-issue at a certain point of the discourse just in case it is on the [Right Frontier (RF)] of the discourse at that time. Content that is AI becomes NAI when knocked off the RF; content that is NAI can become AI if targeted through discourse subordination" (and thus returned to the Right Frontier). And, because discourse referents (propositional and

otherwise) are only accessible for anaphora resolution in SDRT if they are on the Right Frontier, propositional content which is available for anaphoric reference is necessarily at-issue on this account.[89] Thus, we can retain the tight association in the literature between at-issueness and anaphoric potential, but only by reformulating what it means to be at-issue.

However one chooses to define or model at-issueness, it is important to recognize the difference between the at-issue status of a proposition and its anaphoric potential. The two are at least conceptually distinct: at-issueness is about what the main point of an utterance is, while anaphoric potential is about what propositions are available for subsequent anaphoric reference. On some accounts, they coincide, but on others they come apart. Crucially, there is a disparity in the diagnostics frequently used in the literature: some diagnose the at-issue status of a proposition, while others diagnose its anaphoric potential, and these diagnostics don't always agree. How we define and model at-issueness must be sensitive to the issue of availability for propositional anaphora.

[89]This definition also does away with an assumption of Simons et al. 2010, that only one proposition expressed by a clause is at-issue at any given point in a discourse, which results from the Roberts 2009 description of the QUD system. For Hunter & Asher 2016, both a matrix and embedded/appositive clause can be at-issue simultaneously, given the right discourse relation that holds between them. If that discourse relation is subordinating, then both propositions will be on the Right Frontier, and thus both will be at-issue (and potentially available for subsequent anaphoric reference).

CHAPTER 6

CONCLUSION

Anaphoric reference to propositions underlies a great deal of day-to-day communication. We might notice it when we explicitly negotiate about the intended referent of a propositional anaphor like *that*, though the same process is at play even when no such negotation is required, every time we identify the antecedent of a *that* or a *so* or a *which*. And on a deeper representational level, I have argued that embedding verbs, sentential negation, and indeed the declarative mood all make use of a process which is anaphoric on propositions. In this sense, propositional anaphora is core to natural language discourse.

In this dissertation, I have taken a closer look at propositional anaphora, in the hopes of shining a light on a phenomenon which is often overlooked, despite being so fundamental and so prevalent. In Chapter 2, I introduced the concepts of anaphora and propositions, and reviewed the words of English which can be used to make anaphoric reference to propositions. I then argued that propositional anaphora fits firmly within the world of anaphora, as it exhibits most if not all of the same features which have been observed in the nominal, temporal, and modal domains. Propositional anaphora allows for both referential and bound antecedents, allows for linguistic and non-linguistic antecedents, and can be found in 'donkey' contexts. I also discussed examples that show a strict/sloppy identity ambiguity, though more work remains to be done to determine whether a propositional anaphor can be the sloppy variable in such a context without the facilitation of an additional anaphor (e.g., in the examples discussed, a pronoun).

In Chapter 3, I presented a comprehensive investigation into which constructions introduce propositional discourse referents, with the goal of doing for propositions what Karttunen 1969 did for individuals. I showed that most subclausal constructions do not—even those like possessive phrases and intersective adjectives which convey propositional

content (via presupposition and and assertion, respectively)—but that some subclausal constructions do, such as epistemic small clauses. I showed that sentential negation introduces a propositional discourse referent for its prejacent while constituent negation does not, and that epistemic modals do but root modals do not. I also showed that, while matrix declarative and polar interrogative clauses make a proposition available for anaphoric reference, embedded polar interrogatives, (both matrix and embedded) *wh*- and alternative interrogatives, and imperatives, do not. I argued that the generalization of which constructions introduce propositional discourse referents cannot be a syntactic one (like that of Krifka 2013), as some but not all object raising and subject control constructions make a proposition available for anaphoric reference. Ultimately, the generalization must be sensitive to the semantics of a construction, in particular the semantic type of the argument taken by an operator. I then discussed how this generalization might be understood, and how it differentiates propositional anaphora from individual anaphora, as well as how the two are similar, e.g., with respect to formal representation.

This chapter presented some surprising results, and as a consequence raises some interesting questions, many of which remain open for future investigation. For one, the pattern of epistemics—small clause embedding verbs, DP- and VP-adverbs, and auxiliary verbs—is surprising, and raises some questions about how this behavior should be understood. Are these all the result of some post-surface (LF) movement, raising these epistemic morphemes to the same high syntactic position? Or, alternatively, is there a full Cinque 1999 hierarchy at work even in an adverbial modification? And is the same necessary for small clause embedding verbs, or, as discussed earlier, should one take the anaphoric behavior of epistemic small clause constructions as evidence that these small clauses are in fact covert infinitives? These data have consequences not just for how we analyze small clauses or modal auxiliaries—both of which seem less homogeneous than we might otherwise have thought—but also for more general theories of syntax and the syntax-semantics interface.

Chapter 3 also unconvered some surprising behavior among the interrogatives. First, that among the types of interrogatives, only polar interrogatives introduce propositional discourse referents; not even sentential alternative interrogatives, which seem to plainly invoke a disjunction of full tensed clauses, allow for anaphoric reference to one of the alternatives—even while disjunction in declaratives does. But perhaps even more surprising is the disparate behavior of matrix and embedded polar interrogatives: where matrix polar interrogatives introduce a discourse referent for the partitioning proposition, embedded polar interrogatives do not. This demands an explanation—one I have not provided here—and whatever the analysis, will have consequences for how we think about sentence mood, especially in relation to theories of "embedded mood". More broadly, the anaphoric behavior of interrogatives has consequences for how we analyze and model questions in discourse: even absent the "polarity" of response particles, it is not sufficient to model the propositions which make up possible answers to a question as having the same status. And, similarly, we should not model the possible responses to polar questions the same way we model the possible responses to alternative or *wh-* questions, as we have seen them to have different anaphoric behavior.

In Chapter 4, I reviewed a number of formal systems which might be used to model anaphoric reference to propositions. For each system, I discussed what might need to be adapted in order to account for the data presented and the generalization developed in Chapter 3. These included systems which were built to handle anaphora—in particular, individual anaphora—, as well as systems whose logical language already includes propositional variables. I then presented a novel formal system, incorporating insights from many of these existing formalisms, to model the data which is are interest here. Ultimately, the system presented here is compositional at the sentence level; I leave it for future work to present a system which is compositional at the level of the morpheme, and which models anaphoric reference to propositions in parallel with reference to individuals, events, and other domains. Such a system would also ideally represent the different

statuses a proposition can have in relation to a discourse, such as were discussed at the end of Chapter 4, and which were the focus of Chapter 5.

Chapter 5 explored the relationship between a proposition's availability for anaphoric reference and its status in the discourse, i.e., its at-issue status. There has been a tight linking between these two properties presumed in the literature, but I argued that this is not the case. Focusing on the Simons et al. 2010 definition of at-issueness, I discussed the diagnostics presented in Tonhauser 2012 and argued that one of these classes of diagnostics—the direct dissent tests—in fact diagnoses the anaphoric availability of a proposition, not its at-issue status. Using the other two classes of diagnostics, which are QUD-based and thus closer to the QUD-based definition of at-issueness from Simons et al. 2010, I presented novel data to argue that the at-issue status of a proposition and its availability for anaphoric reference are in fact independent. I showed that there are not-at-issue propositions which are nevertheless available for anaphoric reference, indicating that at-issueness is not necessary for anaphoric availability. I also showed examples of at-issue propositions which systematically fail to be available for anaphoric reference, which indicates that at-issue status is also not a sufficient condition for a proposition to be available for anaphora. I then discussed what these data might mean for our conception of at-issueness, including for approaches other than that of Simons et al. 2010.

Ultimately, the data and discussions in Chapters 3 and 5 raise even more questions about the nature of propositional anaphora, in particular about its relation to other types of anaphora. While Chapter 2 argued that propositional anaphora is a kind of anaphora, it also seems different in some crucial ways from other kinds of anaphora. As we saw in Chapter 3, propositional anaphora is not sensitive to truth in the way that individual anaphora is, and in Chapter 5 we saw this insensitivity extended to discourse status more broadly, at least in terms of Simons et al. 2010 at-issueness. (It remains to be seen whether, or to what extent, this gap is closed under an alternative notion of at-issueness,

such as that of Hunter & Asher 2016.) And, while the discourse referents for individual, tense, and modal anaphora seem to be introduced by the antecedent phrases or morphemes which describe individuals, times, and worlds (respectively), propositional anaphora seems to rely not on proposition-denoting clauses but on the operators which take those propositions as arguments. Why this disparity should be, and what other consequences it has for propositional anaphora versus other kinds of anaphora, still remain open questions.

This dissertation represents an advance in what we know about anaphoric reference to propositions, but there is yet more work to be done. In addition to the lingering questions mentioned above, this work invites a rich cross-linguistics examination of the range of variation of this phenomenon. I have only discussed anaphoric reference to propositions *in English*, here. There are parts of this analysis which might well be true across languages—e.g., I would expect the semantic type generalization of Chapter 3 is not just a fact about English—but work must be done to confirm (or deny) those parts. In addition, there are questions about propositional anaphora which simply cannot be answered by looking only at English: What happens in languages with gender, animacy, and other noun class marking on anaphoric pro-forms? What about in languages with richer demonstrative systems (like Korean)? Are there other parts of speech which can serve as propositional anaphors beyond those used by English? There are also questions to be answered about the way propositional anaphora interacts with topicalization (e.g., in cleft constructions) and other discourse structural processes. I hope that this work will spur research into these questions and other related areas.

More broadly, this dissertation represents a case study for how the careful examination of what might be considered a discourse-level phenomenon can provide insight not only into discourse-pragmatic processes, but also into syntactic structure and semantic composition. Paying attention to both the prior discourse context of an utterance—including but

not limited to the current Question under Discussion—as well as the utterance's effects on subsequent discourse—e.g., which types of anaphors are licensed—can tell us more about an utterance than a sentence in isolation can. While there remain open questions about propositional anaphora and the structures which license it, this dissertation provides an argument for why linguistic phenomena should not be studied only in isolation, but should also be considered in a rich discourse context.

APPENDIX A

FORMAL FRAGMENTS

VOCABULARY

- n-place predicates
- individual constants
- individual variables
- negation $\neg$
- conjunction $\wedge$
- disjunction $\vee$
- implication $\rightarrow$
- existential $\exists$
- universal $\forall$
- identity $=$

SYNTAX

1. If $t_1, \ldots, t_n$ are individual constants or variables, R is an n-place predicate, then $Rt_1 \ldots t_n$ is a formula.
2. If t_1 and t_2 are individual constants or variables, then $t_1 = t_2$ is a formula.
3. If ϕ is a formula, then $\neg\phi$ is a formula.
4. If ϕ and ψ are formulas, then $[\phi \wedge \psi]$ is a formula.
5. If ϕ and ψ are formulas, then $[\phi \vee \psi]$ is a formula.
6. If ϕ and ψ are formulas, then $[\phi \rightarrow \psi]$ is a formula.
7. If ϕ is a formula, and x is a variable, then $\exists x\phi$ is a formula.
8. If ϕ is a formula, and x is a variable, then $\forall x\phi$ is a formula.
9. Nothing is a formula except on the basis of 1–8.

SEMANTICS

A model M is a pair $\langle D, F\rangle$, where D is a non-empty set of individuals, F an interpretation function, having as its domain the individual constants and predicates. If α is an individual constant, then $F(\alpha) \in D$; if α is an n-place predicate, then $F(\alpha) \subseteq D^n$. An assignment g is a function assigning an individual to each variable: $g(x) \in D$. G is the set of all assignment functions. Next, we define $[\![t]\!]_g = g(t)$ if t is a variable, and $[\![t]\!]_g = F(t)$ if t is an individual constant.

1. $[\![Rt_1 \ldots t_n]\!] = \{\langle g, h\rangle | h = g \;\&\; \langle [\![t_1]\!]_h \ldots [\![t_n]\!]_h\rangle \in F(R)\}$.
2. $[\![t_1 = t_2]\!] = \{\langle g, h\rangle | h = g \;\&\; [\![t_1]\!]_h = [\![t_2]\!]_h\}$.
3. $[\![\neg\phi]\!] = \{\langle g, h\rangle | h = g \;\&\; \neg\exists k : \langle h, k\rangle \in [\![\phi]\!]\}$.
4. $[\![\phi \wedge \psi]\!] = \{\langle g, h\rangle | \exists k : \langle g, k\rangle \in [\![\phi]\!] \;\&\; \langle k, h\rangle \in [\![\psi]\!]\}$.
5. $[\![\phi \vee \psi]\!] = \{\langle g, h\rangle | h = g \;\&\; \exists k : \langle h, k\rangle \in [\![\phi]\!] \vee \langle h, k\rangle \in [\![\psi]\!]\}$.
6. $[\![\phi \rightarrow \psi]\!] = \{\langle g, h\rangle | h = g \;\&\; \forall k : \langle h, k\rangle \in [\![\phi]\!] \Longrightarrow \exists j : \langle k, j\rangle \in [\![\psi]\!]\}$.
7. $[\![\exists x\phi]\!] = \{\langle g, h\rangle | \exists k : k[x]g \;\&\; \langle k, h\rangle \in [\![\phi]\!]\}$.
8. $[\![\forall x\phi]\!] = \{\langle g, h\rangle | h = g \;\&\; \forall k : k[x]h \Longrightarrow \exists j : \langle k, j\rangle \in [\![\phi]\!]\}$.

ϕ is *true with respect to g in M* iff $\exists h : \langle g, h\rangle \in [\![\phi]\!]_M$.
ϕ is *valid* iff $\forall M \forall g : \phi$ is true with respect to g in M.
ϕ is a *contradiction* if $\forall M \forall g : \phi$ is false with respect to g in M.

Figure 2: Fragment of Dynamic Predicate Logic (Groenendijk & Stokhof 1991)

Figure 3: Fragment of Discourse Representation Theory (Asher 1993)

VOCABULARY

Object language symbols:

$x, y, x_1, \ldots$	individual, eventuality, or plural discourse referent variables
$e, e_1, \ldots$	eventuality discourse referent variables
P, Q, P_1, Q_1, ...	predicative DRS variables
u, x, y, z, x_1, ...	discourse referents (individual type)
loves(,), boy( ), etc.	DRT predicates
$\Rightarrow, \neg, \vee$	DRS operators

Metalinguistic symbols:

$\mathbf{x}$, $\mathbf{y}$, $\mathbf{z}$, $\mathbf{x}_1, \ldots$	variables over individual, eventuality, or plural discourse referents
$\mathbf{e}$, $\mathbf{e}_1, \ldots$	variables over eventuality discourse referents
$\mathbf{t}_1$, $\mathbf{e}_2, \ldots$	variables over temporal discourse referents
$\mathbf{x}, \mathbf{y}, \ldots$	variables over discourse referent variables
$\mathbf{e}, \mathbf{e_1}, \ldots$	variables over eventuality discourse referent variables
$\mathbf{K}$, $\mathbf{K}'$, $\mathbf{K}_1, \ldots$	variables over DRSs
$\mathbf{P}$, $\mathbf{Q}$, $\mathbf{Q}_1, \ldots$	variables over predicative DRS variables
φ, ψ, ζ	variables over DRT predicates
$\mathbf{\Phi}, \mathbf{\Psi}, \mathbf{\Phi_1}, \ldots$	variables over DRT conditions and sets of DRTS conditions

Given the above:

(i) If ψ is n-ary, then $\psi(\mathbf{x}_1, \ldots, \mathbf{x}_n)$ is an atomic condition.

(ii) $\mathbf{x}_1 = \mathbf{x}_2$, $\mathbf{e}_1 < \mathbf{e}_2$, $\mathbf{e}_1 < \mathbf{t}$ are conditions.

(iii) If ψ is a quantifier relation symbol, then the following are conditions: $\neg$K, $K_1 \Rightarrow K_2$, **e**-K, and $K_1 \overset{\psi}{\underset{x}{\diamond}} K_2$.

(iv) If **x** is a discourse referent in U_K, then $\mathbf{X} = \Sigma_{\mathbf{x}}K$ is a condition.

(v) $\mathbf{X} = \mathbf{x}_1 + \ldots + \mathbf{x}_n$ is a condition.

(vi) A DRS is a pair $\langle U, Con \rangle$, where U is a set of discourse referents, and Con a set of conditions.

Conditions that contains subDRSs are complex conditions; those without constituent conditions are simple or atomic conditions. An atomic DRS contains only atomic conditions; otherwise it is complex.

Subordination: If K is a constituent of a complex condition of K′, then K is subordinate to K′. If K_n is a constituent of a complex condition of K_{n-1} and K_{n-1} is subordinate to K, then K_n is subordinate to K.

Accessibility: Let $K = K_0$ or K be subordinate to K_0. Then:

(i) If **x**, **y** $\in U_K$, then **y** is accessible to **x** in K_0;

(ii) if K′ is subordinate to K and **x** $\in U_{K'}$ and **y** $\in U_K$, then **y** is accessible to **x** in K_0;

(iii) if **y** $\in U_{K'}$, **x** $\in U_{K''}$ and $K' \Rightarrow K''$ is a complex condition of K, then **y** is accessible to **x** in K_0;

(iv) otherwise, **y** is not accessible to **x** in K_0.

Figure 3, continued

SEMANTICS

An intentional DRS model M is a quintuple $\langle$ W, T, D, E, $[\![\ ]\!]\rangle$.

(i) W and T are non-empty sets (of worlds and times respectively).

(ii) D is a function from W $\times$ T into a non-empty, atomic lattice ($D_{\langle w,t\rangle}$ is the "domain of individuals and sums of individuals in w at t").

(iii) E is a function from W $\times$ T into a set of objects (eventualities) partially well ordered by inclusion such that:

(a) if ϕ is an E-path description, $\forall e_1 \in E_{\langle w,t_1\rangle} \forall e_2 \in E_{\langle w,t_2\rangle} \ldots \forall e_n \in E_{\langle w,t_n\rangle} (\varphi(e_1, \ldots e_n) \rightarrow \exists e' \in E_{\langle w,t_n\rangle}(e_1 \subset e \& \ldots \& e_n \subset e')$ and

(b) if ψ is an eventuality description,
then $\exists e' \in E_{\langle w,t\rangle} \forall e \in E_{\langle w,t\rangle} \forall x_1, \ldots, x_n \psi(e, x_1, \ldots, x_n) \rightarrow e \subset e')$

$E_{\langle w,t\rangle}$ is the "domain of eventualities in w at t". $\mathrm{Dom}(\langle w, t\rangle) = D_{\langle w,t\rangle} \cup E_{\langle w,t\rangle}$.

(iv) $[\![\ ]\!]$ is an interpretation function that assigns to DRS predicates functions δ such that for $\langle w, t\rangle \in W \times T \delta(\langle w, t\rangle) \in \mathcal{P}(\cup_{n\in\omega}(\mathrm{Dom}(\langle w, t\rangle))^n)$.
To quantifier relation symbols, $[\![\ ]\!]$ assigned functions γ such that for $\langle w, t\rangle \in W \times T$ into $\gamma(\langle w, t\rangle) \in \mathcal{PP}(\cup_{n\in\omega}(\mathrm{Dom}(\langle w, t\rangle)^n))$, where $\mathrm{Dom}(\langle w, t\rangle) = D_{\langle w,t\rangle} \cup E_{\langle w,t\rangle}$.

$e_1 \oplus e_2 = \min_{\subset}\{e' : e_1 \subset e' \& e_2 \subset e'\}$ if there is such an e'; $= 0$ otherwise

Define a *proper embedding* of a DRS K *in* a model M *with respect to* a function from discourse referents into objects in $D_{M\langle w,t\rangle}$. Call any such function from discourse referents into D_M an *embedding function*.

Define an embedding function g to *extend* an embedding function f *relative to* K in M at $\langle w, t\rangle$ (written $g \supseteq_K f$) just in case Dom(g) = Dom(f)$\cup U_K$, g $\supseteq$ f.

Define an *external anchor for* K *in* M to be a partial function from U_K into $(\cup_{\langle w,t\rangle \in W\times T}(\mathrm{Dom}(\langle w, t\rangle)) \cup$ T, such that if n $\in U_K$ then A(n) = the utterance time of the discourse, and if i $\in U_K$A(i) = the speaker of the discourse.

Define a *proper embedding* f *of* K *in* M *at* $\langle w, t\rangle$ (written $[f, K]^M_{w,t}$) with respect to a possibly empty external anchor A for K in M and satisfaction for a condition in M relative to an embedding function f for the DRS in which the conditions occur at $\langle w, t\rangle$ (written (M, w, t)$\models_f$).

Figure 3, continued

SATISFACTION

(i) If ψ is an atomic condition of the form $\phi(\mathbf{x}_1, \ldots, \mathbf{x}_n)$, then (M, w, t)$\models_f \psi$ iff $\langle f(\mathbf{x}_1), \ldots, f(\mathbf{x})_n\rangle \in [\![\phi]\!]^M_{w,t}$.

(ii) If ψ is an atomic condition of the form $\mathbf{x}_1 = \mathbf{x}_2$, then M(M, w, t)$\models_f \psi$ iff $f(\mathbf{x}_1) = f(\mathbf{x}_2)$.

(ii) If ψ is a condition of the form $\mathbf{X} = \mathbf{x}_1 + \ldots + \mathbf{x}_n$, then (M, w, t)$\models_f \psi$ iff $f(\mathbf{X}) = f(\mathbf{x}_1) \oplus \ldots \oplus f(\mathbf{x}_n)$.

(iii) If ψ is a condition of the form $\mathbf{X} = \Sigma \mathbf{x} K_1$, then (M, w, t)$\models_f \psi$ iff $f(\mathbf{X}) = \oplus\{b \in D\langle w, t\rangle : \exists g \supseteq_{K_1} f(g(\mathbf{x}) = b \;\&\; [g, K_1]^M_{w,t,f})\}$.

(iv) If ψ is of the form **e**-K_1, then (M, w, t)$\models_f \psi$ iff $\exists g \supseteq_{K_1} f[g, K_1]^M_{w,t,f})$.

(v) If ψ is a condition of the form $K_1 \Rightarrow K_2$, then (M, w, t)$\models_f \psi$ iff $\forall g \supseteq_{K_1} f([g, K_1]^M_{w,t,f} \rightarrow \exists h \supseteq_{K_2} g[h, K_2]^M_{w,t,g})$.

(vi) If ψ is a condition of the form $K_1 \diamond\!\!\!\!\diamond^{\psi}_{x} K_2$, then (M, w, t)$\models_f \psi$ iff $\langle\{b : \exists g \supseteq_{K_1} f[g, K_1]^M_{w,t,f} \;\&\; g(\mathbf{x}) = b\}, \{b : \exists g \supseteq_{K_1} f[g, K_1]^M_{w,t,f} \;\&\; \exists h \supseteq_{K_2} g[h, K_2]^M_{w,t,g} h(\mathbf{x}) = b\}\rangle \in [\![\phi]\!]^M_{w,t}$.

(vii) If ψ is a condition of the form $\neg K_1$, then (M, w, t)$\models_f \psi$ iff $\neg\exists g \supseteq_{K_1} f[g, K_1]^M_{w,t,f}$.

(viii) If A is an external anchor for K in M, then $[f, K]^M_{w,t,g}$ iff
(i) $f \supseteq_K g$; (ii) $A \subseteq f$; (iii) $\forall\theta \in Con_K$(M, w, t)$\models_f \theta$.

(ix) $[f, K]^M_{w,t}$ iff $[f, K]^M_{w,t,\emptyset}$.

VOCABULARY

- set of information states S^n about n subjects $S^n = \mathcal{P}(D^n)$, where $S = \bigcup_{n \in \mathcal{N}} S^n$
- relation constants R^n of arity n
- individual anaphors $A = \{\mathrm{p}_i \mid i \in \mathcal{N}\}$
- individual constants C
- set of terms $T = \{C, V, A\}$
- conjunction $\wedge$
- individual variables V
- negation $\neg$
- existential $\exists$

For a state $s \in S^n$ and $0 < j \leq n$, and for any case $e = \langle d_1, \ldots, d_n \rangle \in s$, d_j is a possible value of the j-th subject of s, and this value will also be indicated as e_j.
If $e \in D^n$ and $e' \in D^m$, then $e \cdot e' = \langle e_1, \ldots, e_n, e'_1, \ldots, e'_m \rangle \in D^{n+m}$
Extension: $e \leq e'$ iff $\exists e'' : e' = e \cdot e''$
For $s \in S^n$ ($i \in D^n$), N_s ($= N_i$) $= n$, the number of subjects of s (i)
Update: $s \leq s'$ iff $N_s \leq N_{s'}$ and $\forall e' \in s' \exists e \in s : e \leq e'$

SYNTAX

The set L of PLA formulas is the smallest set such that:

1. if $t_1, \ldots, t_n \in T$ and $R \in R^n$, then $Rt_1 \ldots t_n \in L$
2. if $t_1, t_2 \in T$, then $t_1 = t_2 \in L$
3. if $\phi \in L$, then $\neg\phi \in L$
4. if $\phi \in L$ and $x \in V$, then $\exists x\phi \in L$
5. if $\phi, \psi \in L$, then $(\phi \wedge \psi) \in L$

$\forall x\phi$ abbreviates $\neg\exists x\neg\phi$ $\qquad$ $\phi \rightarrow \psi$ abbreviates $\neg(\phi \wedge \neg\psi)$

$s \, [\![\phi]\!]_{\mathcal{M},g}$ is the interpretation of ϕ in info state s with respect to model $\mathcal{M}$ and assignment g.
$[\![\phi]\!]_{\mathcal{M},g}$ is a (partial) update function on info states.

SEMANTICS

A PLA model $M = \langle D, F \rangle$ consists of a non-empty domain D of individuals, and an interpretation function F which assigns individuals in D to individual constants and sets of n-tuples of individuals to n-place relation expressions. Constants and variables are evaluated in the usual way with respect to a model and an assignment function. Pronouns are evaluated relative to an information state s and a case $e \in s$.

- $[c]_{\mathcal{M},s,e,g} = F(c)$ for all constants c
- $[x]_{\mathcal{M},s,e,g} = g(x)$ for all variables x
- $[\mathrm{p}_i]_{\mathcal{M},s,e,g} = e_{N_s - i}$ for all pronouns p_i and e and s such that $e \in s$ and $N_s > i$

If X is a set of terms, then I_x is the smallest number $\geq$ the index of every pronoun in X.

1. $s \, [\![Rt_1 \ldots t_n]\!]_{\mathcal{M},g} = \{e \in s \mid \langle [t_1]_{\mathcal{M},s,e,g}, \ldots, [t_n]_{\mathcal{M},s,e,g} \rangle \in F(R)\}$ (if $N_s > I_{\{t_1,\ldots,t_n\}}$)
2. $s \, [\![t_1 = t_2]\!]_{\mathcal{M},g} = \{e \in s \mid [t_1]_{\mathcal{M},s,e,g} = [t_2]_{\mathcal{M},s,e,g}\}$ (if $N_s > I_{\{t_1,t_2\}}$)
3. $s \, [\![\neg\phi]\!]_{\mathcal{M},g} = \{e \in s \mid \neg\exists e' : e \leq e' \,\&\, e' \in s \, [\![\phi]\!]_{\mathcal{M},g}\}$
4. $s \, [\![\exists x\phi]\!]_{\mathcal{M},g} = \{e' \cdot d \mid d \in D \,\&\, e' \in s \, [\![\phi]\!]_{\mathcal{M},g[x/d]}\}$
5. $s \, [\![\phi \wedge \psi]\!]_{\mathcal{M},g} = s \, [\![\phi]\!]_{\mathcal{M},g} \, [\![\psi]\!]_{\mathcal{M},g}$

Support: $s \models_{\mathcal{M},g} \phi$ iff $\forall e \in s : \exists e' : e \leq e' \,\&\, e' \in s \, [\![\phi]\!]_{\mathcal{M},g}$
Entailment: $\phi_1, \ldots, \phi_n \models \psi$ iff $\forall \mathcal{M}, g \forall s \in S : s \, [\![\phi_1]\!]_{\mathcal{M},g} \ldots s \, [\![\phi_n]\!]_{\mathcal{M},g} \models_{\mathcal{M},g} \psi$ (if defined)

Figure 4: Fragment of Predicate Logic with Anaphora (Dekker 1994)

VOCABULARY & SYNTAX

The vocabulary and syntax of DMPL are like those of DPL, but with a construction for epistemic 'might' added:

DMPL $\pi := Rt \cdots t \mid t = t \mid v :=? \mid \pi;\pi \mid \neg\pi \mid \Diamond\pi$.

SEMANTICS

A DMPL model $\mathcal{M}$ is a pair $\langle M, W\rangle$ where W is a set of first order interpretations over the universe M. Variable assignments for $\mathcal{M}$ are elements of M^V. Index sets for $\mathcal{M}$ are subsets of W.
$[\![\pi]\!]^s_u(I) = J$ means that given input assignment s and output assignment u (for $\mathcal{M}$), π maps index set I to index set J.

1. $[\![Rt_1 \cdots t_n]\!]^s_u(I) = \{i \in I \mid s = u \text{ and } M, i \models_s Rt_1 \cdots t_n\}$
2. $[\![t_1 = t_2]\!]^s_u(I) = \{i \in I \mid s = u \text{ and } M, i \models_s t_1 = t_2\}$
3. $[\![\pi_1;\pi_2]\!]^s_u(I) = \{i \in I \mid \text{there is an } r \text{ with } i \in [\![\pi_2]\!]^r_u([\![\pi_1]\!]^s_r(I))\}$
4. $[\![\neg\pi]\!]^s_u(I) = \{i \in I \mid s = u \text{ and there is no } r \text{ with } i \in [\![\pi]\!]^s_r(I)\}$
5. $[\![v :=?]\!]^s_u(I) = \{i \in I \mid u = s(x|d) \text{ for some } d \in M\}$ (reduces to either I or $\emptyset$)
6. $[\![\Diamond\pi]\!]^s_u(I) = \{i \in I \mid u = s \text{ and there is an } r \text{ with } [\![\pi]\!]^s_r(I) \neq \emptyset\}$ (reduces to either I or $\emptyset$)

   $[\![\Diamond\pi_1 \Rightarrow \pi_2]\!]^s_u(I) = \{i \in I \mid s = u \text{ and } \forall r \text{ with } i \in [\![\pi_1]\!]^s_r(I)\ \exists p \text{ with } i \in [\![\pi_2]\!]^s_p([\![\pi_1]\!]^s_r(I))\}$

A program π is acceptable (in $\mathcal{M}$) for inputs I and s if there is an u for which $[\![\pi]\!]^s_u(I) \neq 1$.
A program π is accepted by I, given s, if there is an u for which $[\![\pi]\!]^s_u(I) = 1$.
A program π is valid if for all models $\mathcal{M}$, for all I, s for $\mathcal{M}$, π is accepted by I, given s.

Figure 5: Fragment from van Eijck & Cepparello 1994

DEFINITION OF TERMS

A *referent system* is a function r, which has as its domain a finite set of variables v, and as its range a number of pegs. If the number of pegs in a referent system is n, then the numbers $m < n$ are its pegs. The quantifier $\exists x$ adds the variable x to the domain, introduces the next peg, and associates x with that peg.

$r[x/n]$ is the referent system r' which is like r, except that its domain is $v \cup \{x\}$, and its range is $n + 1$, and $r'(x) = n$. If x is already present in r, it is associated with the new peg; the peg that x had been connected with before remains, but is no longer associated with a variable.

Extension: Let r and r' be two referent systems with domains v and v', ranges n and n', respectively. r' is an extension of r, $r \leq r'$, iff $v \subseteq v'; n \leq n'$; if $x \in v$ then $r(x) = r'(x)$ or $n \leq r'(x)$; if $x \notin v$ and $x \in v'$ then $n \leq r'(x)$.

Possibilities: Let D, the *domain of discourse*, and W, the set of *possible worlds*, be two disjoint non-empty sets. The *possibilities* based on D and W is the set of I of triples $\langle r, g, w\rangle$, where r is a referent system; g is a function from the range of r into D; $w \in W$.

Let α be a basic expression, $i = \langle r, g, w\rangle \in I$, with v the domain of r, and I based upon W and D. The *denotation* of α in i is defined as:

i. If α is an individual constant, then $i(\alpha) = w(\alpha) \in D$.

ii. If α is an n-place predicate, then $i(\alpha) = w(\alpha) \subseteq D^n$.

iii. If α is a variable such that $\alpha \in v$, then $i(\alpha) = g(r(\alpha)) \in D$, else $i(\alpha)$ is not defined.

Information states: Let I be the set of possibilities based on D and W. The set of *information states* based on I is the set S s.t. $s \in S$ iff $s \subseteq I$, and $\forall i, i' \in s : i$ and i' have the same referent system.

Information growth: Let $i = \langle r, g, w\rangle \in I$; n the range of r; $d \in D$, $s \in S$.

i. $i[x/d] = \langle r[x/n], g[n/d], w\rangle$ ii. $s[x/d] = \{o[x/d] \mid i \in s\}$

Extension: Let $i, i' \in I$, $i = \langle r, g, w\rangle$ and $i' = \langle r', g', w'\rangle$, and $s, s' \in S$.

i. i' is an extension of i, $i \leq i'$ iff $r \leq r'$, $g \subseteq g'$, and $w = w'$.

ii. s' is an extension of s, $s \leq s'$ iff $\forall i' \in s' : \exists i \in s : i \leq i'$.

Let $s, s' \in S$, $s \leq s'$, $i \in s$, $i' \in s'$.

i. i' is a *descendant of* i *in* s' iff $i \leq i'$.

ii. i *subsists in* s' iff i has one or more descendants in s'.

iii. s *subsists in* s' iff all $i \in s$ subsist in s'.

SEMANTICS

A formula ϕ of this language is interpreted as a (partial) function, $[\phi]$, from information states to information states. Postfix notation is used: $s[\phi]$ is the result of updates s with ϕ.

Let $s \in S$ be an information state, and ϕ a formula of the language. The *update of* s *with* ϕ is recursively defined as follows:

i. $s[Rt_1 \ldots t_n] = \{i \in s \mid \langle i(t_1), \ldots, i(t_n)\rangle \in i(R)\}$

ii. $s[t_1 = t_2] = \{i \in s \mid i(t_1) = i(t_2)\}$

iii. $s[\neg\phi] = \{i \in s \mid i$ does not subsist in $s[\phi]\}$

iv. $s[\phi \wedge \psi] = s[\phi][\psi]$

v. $s[\exists x\phi] = \cup_{d \in D}(s[x/d][\phi])$

vi. $s[\Diamond\phi] = \{i \in s \mid s[\phi] \neq \emptyset\}$

Figure 6: Fragment from Groenendijk et al. 1995b, 1996

Figure 7: Fragment of Update with Centering (Bittner 2009)

VOCABULARY

- $\langle D \rangle^{n,m} = D^n \times D^m$ is the set of $\top\bot$-lists of n topical objects and m background objects
- For any $\top\bot$-list $\mathsf{i} = \langle \mathsf{i}_1, \mathsf{i}_2 \rangle \in \langle D \rangle^{n,m}$, $\top\mathsf{i} = \mathsf{i}_1$ and $\bot\mathsf{i} = \mathsf{i}_2$. Thus, $\mathsf{i} = \langle \top\mathsf{i}, \bot\mathsf{i} \rangle$.
- An n, m-*infotention state* is any subset of $\langle D \rangle^{n,m}$. The null set, $\emptyset$, is the *absurd state*.

Discourse deferents for propositions (type ωt), worlds (ω), individuals, (δ), events (ε), states (σ), times (τ). These compose $(\Theta|5)$. A $\top\bot$-list is an object of type s.
The set of UC *types* Θ is the smallest set such that

(i) $\{t, \omega, \delta, \varepsilon, \sigma, \tau\} \subseteq \Theta$, (ii) $(ab) \in \Theta$, and (iii) $s \in \Theta$.

- common ground p_0
- run time ϑ
- temporal precedence $<$
- beginning BEG
- end END
- speech event e_0
- place π
- consequent state CON
- experiencer DAT
- center CTR

SYNTAX

Define for each type $a \in \Theta$ the set of a-terms as follows:

1. $Con_a \cup Var_a \subseteq Term_a$
2. $\lambda u_a(B) \in Term_{ab}$, if $u_a \in Var_a$ and $B \in Term_b$
3. $BA \in Term_b$, if $B \in Term_{ab}$ and $A \in Term_a$
4. $\neg A, (A \to B), (A \wedge B), (A \vee B) \in Term_t$, if $A, B \in Term_t$
5. $\forall u_a B, \exists u_a B \in Term_t$, if $u_a \in Var_a$ and $B \in Term_t$
6. $(A = B) \in Term_t$, if $A, B \in Term_a$
7. $(u_a{}^{\top}\!\oplus B), (u_a{}^{\bot}\!\oplus B) \in Term_s$, if $a \in (\Theta|5)$, $u_a \in Var_a$, and $B \in Term_s$
8. $\top a, \bot a \in Term_{sa}$, if $a \in (\Theta|5)$
9. $A\{B\} \in Term_{at}$, if $a \in (\Theta|5)$, $A \in Term_{sa}$, and $B \in Term_{st}$
10. $(A\ ;\ B), (A\ ^{\top}\!;\ B), (A\ ^{\bot}\!;\ B) \in Term_{(st)st}$, if $A, B \in Term_{(st)st}$
11. $(A \subset B), (A < B) \in Term_t$, if $A, B \in Term_t$
12. CON $A \in Term_\sigma$, if $A \in Term_\varepsilon$
    BEG A, END $A \in Term_\varepsilon$, if $A \in Term_\sigma$
    CTR A, DAT $A \in Term_\delta$, if $A \in Term_\varepsilon \cup Term_\sigma$
13. $\vartheta(W, A) \in Term_\tau$, if $W \in Term_\omega$ and $A \in Term_\varepsilon \cup Term_\sigma$
    $\pi(W, A) \in Term_\delta$, if $W \in Term_\omega$ and $A \in Term_\varepsilon \cup Term_\sigma$

Figure 7, continued

FRAMES

A UC frame is a set $\{D_a | a \in \Theta\}$ of non-empty pairwise disjoint sets where:

(i) $D_t = \{1, 0\}$, D_τ is the set of non-empty convex sets of integers;

(ii) $D_a, b = \{f | \emptyset \subset \text{Dom} f \subseteq D_a \wedge \text{Ran} f \subseteq D_b\}$; and

(iii) $D_s \cup_{n,m \geq 0} \langle D \rangle^{n,m}$, with $D = \cup_{a \in (\Theta | 5)} D_a$.

${}^{\{\}}f$ is the set characterized by function f ${}^{\chi}A$ is the characteristic function of set A

MODELS

A UC-model is a structure $M = \langle \{D_a | a \in \Theta\}, <_t, \mathsf{p}_0, \mathsf{e}_0, [\![\cdot]\!] \rangle$, where:

(i) $\{D_a | a \in \Theta\}$ is a UC frame;

(ii) for all $\mathsf{t}, \mathsf{t}' \in D_\tau$, $\mathsf{t} <_\tau \mathsf{t}'$ iff $\forall n \in \mathsf{t} \forall n' \in \mathsf{t}' : n < n'$;

(iii) $\mathsf{p}_0 \in D_{\omega t} \backslash \{\emptyset\}$ and $\mathsf{e}_0 \in D_\varepsilon$; and

(iv) $[\![\cdot]\!]$ assigns to each $A \in \mathit{Con}_a$ a value $[\![A]\!] \in D_a$ and
to each $B \in \{\text{CON}, \text{BEG}, \text{END}, \text{CTR}, \text{DAT}, \vartheta, \pi\}$ a value $[\![B]\!]$ such that:

(a) $[\![\text{CON}]\!] \in D_{\varepsilon\sigma}, [\![\text{BEG}]\!], [\![\text{END}]\!] \in D_{\sigma\varepsilon}, [\![\text{CTR}]\!], [\![\text{DAT}]\!] \in \{f_\varepsilon \cup f_\sigma | f_\varepsilon \in D_{\varepsilon\delta} \wedge f_\sigma \in D_{\sigma\delta}\}$,
$[\![\vartheta]\!] \in \{f_\varepsilon \cup f_\sigma | f_\varepsilon \in D_{\omega\varepsilon\tau} \wedge f_\sigma \in D_{\omega\sigma\tau}\}, [\![\pi]\!] \in \{f_\varepsilon \cup f_\sigma | f_\varepsilon \in D_{\omega\varepsilon\delta} \wedge f_\sigma \in D_{\omega\sigma\delta}\}$

(b) $\forall \mathsf{w} \in D_\omega, \mathsf{a} \in D_\delta, \mathsf{e} \in D_\varepsilon, \mathsf{s} \in D_\sigma, \mathsf{ev} \in D_\varepsilon \cup D_\sigma, \mathsf{t} \in D_\tau$:
$[\![\vartheta]\!](\mathsf{w},\mathsf{e}) = \mathsf{t} \rightarrow \exists n : \mathsf{t} = \{n\} \wedge [\![\vartheta]\!](\mathsf{w}, [\![\text{BEG}]\!]([\![\text{CON}]\!](\mathsf{e}))) = \{(n+1)\}$
$[\![\vartheta]\!](\mathsf{w},\mathsf{s}) = \mathsf{t} \rightarrow \{\min_< \mathsf{t}\} = [\![\vartheta]\!](\mathsf{w}, [\![\text{BEG}]\!](\mathsf{s})) <_\tau [\![\vartheta]\!](\mathsf{w}, [\![\text{END}]\!](\mathsf{s})) = \{\max_< \mathsf{t}\}$

(c) $[\![\text{CTR}]\!](\mathsf{ev}) = \mathsf{a} \rightarrow [\![\text{CTR}]\!]([\![B]\!](\mathsf{ev})) = \mathsf{a}$ for $B \in \{\text{CON}, \text{BEG}, \text{END}\}$
$\langle \mathsf{ev}, \mathsf{a}, \ldots \rangle \in {}^{\{\}}[\![A]\!](\mathsf{w}) \rightarrow [\![\text{CTR}]\!](\mathsf{ev}) = \mathsf{a}$ for $A \in \mathit{Con}_{\omega\varepsilon\delta\ldots t} \cup \mathit{Con}_{\omega\sigma\delta\ldots t}$

(d) $\exists \mathsf{t} \forall \mathsf{w} \in {}^{\{\}}\mathsf{p}_0 : t = [\![\vartheta]\!](\mathsf{w}, \mathsf{e}_0) \wedge \langle \mathsf{e}_0, [\![\text{CTR}]\!](\mathsf{e}_0) \rangle \in {}^{\{\}}[\![\mathit{spk}]\!](\mathsf{w})$

The pair $\langle \mathsf{p}_0, \mathsf{e}_0 \rangle$ is the *utterance context* of M.
The *default infotention state* ${}^*\langle \mathsf{p}_0, \mathsf{e}_0 \rangle := {}^{\chi}\{\langle \langle \mathsf{t}, \mathsf{w}, \mathsf{p}_0, \mathsf{e}_0 \rangle, \langle\ \rangle \rangle \mid \mathsf{w} \in {}^{\{\}}\mathsf{p}_0 \wedge \mathsf{t} = [\![\vartheta]\!](\mathsf{w}, \mathsf{e}_0)\}$

ABBREVIATIONS

i.	$(\mathsf{x})_n$	=	the nth coordinate, x_n	for $\mathsf{x} \in D^{n+m}, n \geq 1$
	$(\mathsf{x})_a$	=	the subsequence consisting of $\mathsf{x}_i \in D_a$	for $\mathsf{x} \in D^n, a \in \Theta$
ii.	$(\mathsf{d} \oplus \mathsf{x})$	=	$\langle \mathsf{d}, \mathsf{x}_1, \ldots, \mathsf{x}_n \rangle$	for $\mathsf{d} \in D, \mathsf{x} \in D^n$
	$\mathsf{y} > \mathsf{x}$	iff	$\mathsf{y} = (\mathsf{y}_1 \oplus \ldots (\mathsf{y}_n \oplus \mathsf{x}))$	for $\mathsf{x} \in D^n, \mathsf{y} \in D^{n+m}$
	$\mathsf{y} \geq \mathsf{x}$	iff	$\mathsf{y} > \mathsf{x} \vee \mathsf{y} = \mathsf{x}$	for $\mathsf{x} \in D^n, \mathsf{y} \in D^m$

Figure 7, continued

SEMANTICS

$X \doteq Y$ reads as 'X is Y if Y is defined, else X is undefined'

i.	$[\![A]\!]^g$	$=$	$[\![A]\!]$	for any $A \in Con_a$
	$[\![u]\!]^g$	$=$	$g(u)$	for any $u \in Var_a$
ii.	$[\![\lambda u_a(B)]\!]^g(\mathsf{d})$	$\doteq$	$[\![B]\!]^{g[u/\mathsf{d}]}$	for any $\mathsf{d} \in D_a$
iii.	$[\![BA]\!]^g$	$\doteq$	$[\![B]\!]^g([\![A]\!]^g)$	
iv.	$[\![\neg A]\!]^g$	$\doteq$	$1 \backslash [\![A]\!]^g$	
	$[\![(A \to B)]\!]^g$	$\doteq$	$1 \backslash ([\![A]\!]^g \backslash [\![B]\!]^g)$	
	$[\![(A \wedge B)]\!]^g$	$\doteq$	$[\![A]\!]^g \cap [\![B]\!]^g$	
	$[\![(A \vee B)]\!]^g$	$\doteq$	$[\![A]\!]^g \cup [\![A]\!]^g$	
v.	$[\![\forall u_a A]\!]^g$	$\doteq$	$\bigcap_{\mathsf{d} \in D_a} [\![A]\!]^{g[u/\mathsf{d}]}$	
	$[\![\exists u_a A]\!]^g$	$\doteq$	$\bigcup_{\mathsf{d} \in D_a} [\![A]\!]^{g[u/\mathsf{d}]}$	
vi.	$[\![A_a = B_a]\!]^g$	$\doteq$	$\lvert\{\langle \mathsf{d}, \mathsf{d}' \rangle \in {D_a}^2 \mid \mathsf{d} = [\![A]\!]^g \wedge \mathsf{d}' = [\![B]\!]^g \wedge \mathsf{d} = \mathsf{d}'\}\rvert$	
vii.	$[\![{u_a}^{\top} \oplus B]\!]^g$	$\doteq$	$\langle (g(u_a) \oplus \top [\![B]\!]^g), \bot [\![B]\!]^g \rangle$	
	$[\![{u_a}^{\bot} \oplus B]\!]^g$	$\doteq$	$\langle \top [\![B]\!]^g, (g(u_a) \oplus \bot [\![B]\!]^g) \rangle$	
viii.	$[\![\top a]\!]^g(\mathsf{i})$	$\doteq$	$((\top \mathsf{i})_a)_1$	for any $\mathsf{i} \in D_s$
	$[\![\bot a]\!]^g(\mathsf{i})$	$\doteq$	$((\bot \mathsf{i})_a)_1$	for any $\mathsf{i} \in D_s$
ix.	$[\![A\{B\}]\!]^g$	$\doteq$	$^{\chi}\{[\![A]\!]^g(\mathsf{i}) \mid \mathsf{i} \in {}^{\{\}}[\![B]\!]^g\}$	
x.	$\mathsf{c}[\![A; B]\!]^g$	$\doteq$	$\mathsf{c}[\![A]\!]^g[\![B]\!]^g$	for any $\mathsf{c} \in D_{st}$
	$\mathsf{c}[\![A\ ^{\top};\ B]\!]^g$	$\doteq$	$\{\mathsf{l} \in \mathsf{c}[\![A; B]\!]^g \mid \exists a \forall \mathsf{k} \in \mathsf{c}[\![A; B]\!]^g\ \exists \mathsf{j} \in \mathsf{c}[\![A; B]\!]^g\ \exists \mathsf{i} \in c\ \exists \mathsf{d} \in D_a :$ $\top \mathsf{k} \geq \top \mathsf{j} > \top \mathsf{i} \wedge (\top \mathsf{j})_1 = \mathsf{d} \wedge [\![B]\!]^g \neq [\![B[\top a/\bot a]]\!]^g \wedge [\![\top a]\!]^g(\mathsf{k}) = d\}$	
	$\mathsf{c}[\![A\ ^{\bot};\ B]\!]^g$	$\doteq$	$\{\mathsf{l} \in \mathsf{c}[\![A; B]\!]^g \mid \exists a \forall \mathsf{k} \in \mathsf{c}[\![A; B]\!]^g\ \exists \mathsf{j} \in \mathsf{c}[\![A; B]\!]^g\ \exists \mathsf{i} \in c\ \exists \mathsf{d} \in D_a :$ $\bot \mathsf{k} \geq \bot \mathsf{j} > \bot \mathsf{i} \wedge (\bot \mathsf{j})_1 = \mathsf{d} \wedge [\![B]\!]^g \neq [\![B[\bot a/\top a]]\!]^g \wedge [\![\bot a]\!]^g(\mathsf{k}) = d\}$	
xi.	$[\![A \subset B]\!]^g$	$\doteq$	$\lvert\{\langle \mathsf{t}, \mathsf{t}' \rangle \in {D_\tau}^2 \mid \mathsf{t} = [\![A]\!]^g \wedge \mathsf{t}' = [\![B]\!]^g \wedge \mathsf{t} \subset \mathsf{t}'\}\rvert$	
	$[\![A < B]\!]^g$	$\doteq$	$\lvert\{\langle \mathsf{t}, \mathsf{t}' \rangle \in {D_\tau}^2 \mid \mathsf{t} = [\![A]\!]^g \wedge \mathsf{t}' = [\![B]\!]^g \wedge \mathsf{t} <_\tau \mathsf{t}'\}\rvert$	
xii.	$[\![BA]\!]^g$	$\doteq$	$[\![B]\!]^g([\![A]\!]^g)$	
xiii.	$[\![B(W, A)]\!]^g$	$\doteq$	$[\![B]\!]^g([\![W]\!]^g, [\![A]\!]^g)$	

Given a state c, an $(st)st$ term K adds the *primary topics* $\top_{\mathsf{c}} K = \{(\top \mathsf{j})_1 \mid \forall g : \mathsf{j} \in {}^{\{\}}(\mathsf{c}[\![K]\!]^g) \wedge \mathsf{j} \notin {}^{\{\}}\mathsf{c}\}$.
K is *true* in c at w iff $\exists \mathsf{p} \in D_\Omega : \top_{\mathsf{c}} K = \{\mathsf{p}\} \wedge \mathsf{w} \in {}^{\{\}}\mathsf{p}$;
K is *false* in c at w iff $\exists \mathsf{p} \in D_\Omega : \top_{\mathsf{c}} K = \{\mathsf{p}\} \wedge \mathsf{w} \notin {}^{\{\}}\mathsf{p}$; else K does not have a truth value.

VOCABULARY

- countable set of propositional variables $V = \{\mathbf{p}_1, \mathbf{p}_2, \ldots\}$
- disjunction $\vee$
- necessarily $\Box$
- brackets (and)
- negation $\sim$
- universal quantifier $(\mathbf{p})$

SEMANTICS

A structure $\mathcal{A}$ is an ordered triple (W, P, v), where W (worlds) is a non-empty set, P (propositions) is a non-empty set of subsets of W, and v (valuation) is a map from V into P.
For a structure $\mathcal{A} = (W, P, v)$, a world x in W, formulas **B** and **C**, and $i = 1, 2, \ldots$:

(i) $\models^{\mathcal{A}}_{x} \mathbf{p}_i$ iff $x \in v(\mathbf{p}_i)$;

(ii) $\models^{\mathcal{A}}_{x} \sim \mathbf{B}$ iff not $\models^{\mathcal{A}}_{x} \mathbf{B}$;

(iii) $\models^{\mathcal{A}}_{x} \mathbf{B} \vee \mathbf{C}$ iff $\models^{\mathcal{A}}_{x} \mathbf{B}$ or $\models^{\mathcal{A}}_{x} \mathbf{C}$;

(iv) $\models^{\mathcal{A}}_{x} \Box\mathbf{B}$ iff $\models^{\mathcal{A}}_{y} \mathbf{B}$ for all y in W;

(v) $\models^{\mathcal{A}}_{x} (\mathbf{p}_i)\mathbf{B}$ iff $\models^{\mathcal{A}'}_{x} \mathbf{B}$ for all structures $\mathcal{A}' = (W, P, v')$ such that $v'(\mathbf{p}_i) = v(\mathbf{p}_j)$ for all $i \neq j$.

A formula **A** is *valid* in $\mathcal{A}$, $\models^{\mathcal{A}}$, if $\models^{\mathcal{A}}_{y}$ for all y in W.

Figure 8: Fragment from Fine 1970

VOCABULARY

For the language L_0^A:

- finite set of atomic sentences A
- sentential variables
- negation $\neg$
- conjunction $\wedge$
- disjunction $\vee$
- parentheses ( )

The language L_1^A also has the unary operator *might*. L_2^A adds *normally* and *presumably*.

SYNTAX

An update system is a triple, $\langle L, \Sigma, [], $ where L is a language, Σ a set of relevant information states, and $[\,]$ a function that assigns to every sentence ϕ an operation $[\phi]$.
$\sigma[\phi]$ is a state σ updated with ϕ. Let W be the powerset of the set A of atomic sentences:

(i) σ is an *information state* iff $\sigma \subseteq W$;

(ii) **0**, *the minimal state*, is the information state given by W;
1, *the absurd state*, is the information state given by $\emptyset$;

(iii) for every two states σ and τ, $\sigma + \tau = \sigma \cap \tau$.

For every sentence ϕ of L_1^A and state σ, $\sigma[\phi]$ is determined as follows:

atoms:	$\sigma[p] = \sigma \cap \{w \in W \mid p \in w\}$
$\neg$:	$\sigma[\neg\phi] = \sigma \sim \sigma[\phi]$
$\wedge$:	$\sigma[\phi \wedge \psi] = \sigma[\phi] \cap \sigma[\psi]$
$\vee$:	$\sigma[\phi \vee \psi] = \sigma[\phi] \cup \sigma[\psi]$
might:	$\sigma[\textit{might } \phi] = \sigma$ if $\sigma[\phi] \neq 1$
	$\sigma[\textit{might } \phi] = 1$ if $\sigma[\phi] = 1$

If $\sigma[\phi] \neq \mathbf{1}$, ϕ is *acceptable in* σ. If $\sigma[\phi] = \mathbf{1}$, ϕ is *not acceptable in* σ. If $\sigma[\phi] = \sigma$, ϕ is *accepted in* σ.
A sequence of sentences $\phi_1, \ldots, \phi_n$ is *consistent* iff there is an information state σ such that $\sigma[\phi_1] \cdots [\phi_n] \neq \mathbf{1}$.

SEMANTICS

For a sentence ϕ of L_0^A, $\mathbf{0}[\phi]$ is *the proposition expressed by* ϕ, abbreviated $[\![\phi]\!]$.

$$\begin{array}{rcl} [\![p]\!] & = & \{w \in W \mid p \in w\} \\ [\![\neg\phi]\!] & = & W \sim [\![\phi]\!] \\ [\![\phi \wedge \psi]\!] & = & [\![\phi]\!] \cap [\![\psi]\!] \\ [\![\phi \vee \psi]\!] & = & [\![\phi]\!] \cup [\![\psi]\!] \end{array}$$

For L_2^A, take a state σ to be a pair $\langle \varepsilon, s \rangle$, where $s \in W$ and ε is an (*expectation*) *pattern* on W: a reflexive and transitive relation on W.
If ε and ε' are patterns on W, and $e \subseteq W$:

(i) ε' is a *refinement* of ε iff $\varepsilon' \subseteq \varepsilon$;

(ii) $\varepsilon \circ e = \{\langle v, w \rangle \in \varepsilon \mid \text{if } w \in e, \text{ then } v \in e\}$; $\varepsilon \circ e$ is the *refinement of* ε *with the proposition* e.

For every sentence ϕ of L_2^A, $\sigma[\phi]$ is determined as follows:

if ϕ is a sentence of L_0^A, then	if $\phi =$ *normally* ϕ, then	if $\phi =$ *presumably* ϕ, then
• if $s \cap [\![\phi]\!] = \emptyset$, then $\sigma[\phi] = \mathbf{1}$;	• if $\mathbf{n}\varepsilon \cap [\![\phi]\!] = \emptyset$, then $\sigma[\phi] = \mathbf{1}$;	• if $\mathbf{m}_\sigma \cap [\![\phi]\!] = \mathbf{m}_\sigma$, $\sigma[\phi] = \sigma$;
• otherwise, $\sigma[\phi] = \langle \varepsilon, s \cap [\![\phi]\!] \rangle$	• otherwise, $\sigma[\phi] = \langle \varepsilon \circ [\![\phi]\!], s \rangle$	• otherwise, $\sigma[\phi] = \mathbf{1}$

Figure 9: Fragment from Veltman 1996

Figure 10: Fragment from Geurts 1998

VOCABULARY

Terms

a. $\mathrm{T} = \mathrm{RM}_i \cup \mathrm{RM}_p \cup \mathrm{T}_p$ (terms)

b. $\mathrm{RM}_i = \{\mathrm{u}, \mathrm{v}, \mathrm{w}, \ldots, \mathrm{u}', \mathrm{u}'', \ldots\}$ (individual reference markers)

c. $\mathrm{RM}_p = \{\mathrm{p}, \mathrm{q}, \mathrm{r}, \ldots, \mathrm{p}', \mathrm{p}'', \ldots\}$ (propositional reference markers)

d. $\mathrm{T}_p = \{p + \varphi \mid p \in \mathrm{RM}_p \text{ and } \varphi \text{ is a DRS}\}$ (complex propositional terms)

DRSs and DRS-conditions

a. A DRS φ is a pair $\langle \mathrm{U}(\varphi), \mathrm{Con}(\varphi)\rangle$, where $\mathrm{U}(\varphi) \in \mathrm{RM}_i \cup \mathrm{RM}_p$, and $\mathrm{Con}(\varphi)$ is a set of DRS-conditions.

b. If P is an n-place predicate, and $\alpha_1, \ldots, \alpha_n \in \mathrm{T}$, then $\mathrm{P}\alpha_1, \ldots, \alpha_n$ is a DRS-condition.

c. If $\alpha \in \mathrm{RM}_i \cup \mathrm{RM}_p$ and $\beta \in \mathrm{T}$, then $\alpha = \beta$ is a DRS-condition.

d. If φ and ψ are DRSs, then $\neg\varphi, \varphi \Rightarrow \psi$, and $\varphi \vee \psi$ are DRS-conditions.

ACCESIBILITY

Extension: For any φ, $\geqslant_\varphi$ is the smallest preorder on propositional terms for which the following hold, for all $\psi \leqslant \varphi$, and $p, q \in \mathrm{RM}_p \cup \mathrm{T}_p$:

a. If $p = q + \chi \in \mathrm{Con}(\psi)$, then $q \leqslant_\varphi p$

b. If $p = q \in \mathrm{Con}(\psi)$, then $p \leqslant_\varphi q$ and $q \leqslant_\varphi p$

Strict accessibility: $\leqslant$ is the smallest preorder for which the following hold:

a. If $\neg\psi \in \mathrm{Con}(\varphi)$, then $\varphi \leqslant \psi$

b. If $\psi \vee \chi \in \mathrm{Con}(\varphi)$, then $\varphi \leqslant \psi$ and $\varphi \leqslant \chi$

c. If $\psi \Rightarrow \chi \in \mathrm{Con}(\varphi)$, then $\varphi \leqslant \psi \leqslant \chi$

d. If $p + \psi \leqslant_\varphi q + \chi$, then $\psi \leqslant \chi$

Accessible domains: The accessible domain of a DRS φ is the set of references markers that are visible from φ: $\mathrm{Acc}(\varphi) = \bigcup_{\psi \geqslant \varphi} \mathrm{U}(\psi)$

Figure 10, continued

SEMANTICS

Embedding functions: Let M be a model with a set of worlds W and a domain of individuals D_w for each $w \in \mathrm{W}$. Then:

1. $\mathrm{F}^0_{\mathrm{M}} = \{f \mid \exists \mathrm{X} \subseteq \mathrm{RM}_i, f : \mathrm{X} \to \bigcup_{w \in \mathrm{W}} \mathrm{D}_w\}$
2. $\mathrm{F}^n_{\mathrm{M}} = \{f \cup g \mid f \in \mathrm{F}^0_{\mathrm{M}} \,\&\, \exists \mathrm{X} \subseteq \mathrm{RM}_p, g : \mathrm{X} \to \mathrm{Pow}(\mathrm{W} \times \mathrm{F}^{n-1}_{\mathrm{M}})\}$, for all $n > 0$

Let $\mathrm{M} = \langle \mathrm{W}, \mathrm{D}, \mathrm{dox}, \mathrm{I} \rangle$ be a model, where W is a set of worlds, D is a function that assigns a domain of individuals D_w to each $w \in \mathrm{W}$, dox a partial function from $\mathrm{W} \times \mathrm{D}$ to Pow(W) and I an interpretation function. Let $s = \langle w, f \rangle$ be an indexed world, where $w \in \mathrm{W}$ and $f \in \mathrm{F}^n_{\mathrm{M}}$, for some $n \geqslant 0$. Then:

a. $\|\alpha\|_s = f(\alpha)$, if $\alpha \in \mathrm{RM}_i \cup \mathrm{RM}_p$; undefined otherwise

b. $\|p + \varphi\|_s = \{s' \mid \exists s' \in \|p\|_s : s' \in \|\varphi\|_{s'}\}$

c. $\|\varphi\|_s = \{\langle w, g \rangle \mid f \subseteq g \,\&\, \mathrm{dom}(g) = \mathrm{Acc}(\varphi) \,\&\, \forall \psi \in \mathrm{Con}(\varphi), \|\psi\|_{\langle w,g \rangle} = 1\}$

d. $\|\mathrm{P}\alpha_1 \ldots \alpha_n\|_s = 1$ iff $\langle \|\alpha_1\|_s, \ldots, \|\alpha_n\|_s \rangle \in \mathrm{I}_w(\mathrm{P})$

e. $\|\alpha = \beta\|_s = 1$ iff $\|\alpha\|_s = \|\beta\|_s$

f. $\|\neg\varphi\|_s = 1$ iff $\|\varphi\|_s = \emptyset$

g. $\|\varphi \vee \psi\|_s = 1$ iff $\|\varphi\|_s \cup \|\psi\|_s \neq \emptyset$

h. $\|\varphi \Rightarrow \psi\|_s = 1$ iff $\forall s' \in \|\varphi\|_s : \|\psi\|_{s'} \neq \emptyset$

VOCABULARY

Types: **e** (individuals), τ (times), ε (eventualities), **w** (worlds), **s** (states of a discourse model)
Discourse markers: functions from stores to objects (of any type, including here **e**, τ, ε, and (**wt**))
Existence predicate, e **in** w, says that event or entity e exists in world w.
Marker predicate **mk** is true of discourse markers.
A ternary relation on worlds, **closer**(w, w', w''), says that w' is more like w than w'' is.

SEMANTICS

if(ω_1, ω_2, K)	$\lambda ij.\exists k(i[\omega_1 : \omega_2]k \wedge Kkj) \wedge \forall hk(i[\omega_1 : \omega_2]k \wedge Kkh) \supset$ $\forall ww_1(w_1 \in \omega_1 iw \supset (\omega_2 hw_1 \subseteq \omega_2 jw_1 \vee$ $\exists w_2 w_3(w_2 \in \omega_2 jw_1 \wedge w_3 \in \omega_2 hw_1 \wedge$ **closer**$(w_1, w_2, w_3))))$
not(ω_1, ω_2)	$\lambda i.\forall ww_1(w_1 \in \omega_1 iw \supset \neg(w_1 \in \omega_2 iw_1))$
may(ω_1, ω_2)	$\lambda i.\forall ww_1(w_1 \in \omega_1 iw \wedge w_1 \in \omega_2 iw_1)$
$\text{if}^{\omega,i}$	$\lambda\mathcal{K}\lambda\mathcal{J}\lambda t\lambda\omega.$**if**$(\omega, \omega_i, \mathcal{K}t\omega_i)\ ;\ \mathcal{J}\omega_i$
$\text{not}^{\omega,i}$	$\lambda\mathcal{K}\lambda t\lambda\omega.$**if**$(\omega, \omega_i, \mathcal{K}t\omega_i)\ ;[\ \mid$ **not**$(\omega, \omega_i)]$

Figure 11: Fragment from Stone & Hardt 1999

SEMANTICS

A model M is a quintuple (W, R, P, D, I), where W is a non-empty set of worlds, R is an accessibility relation, P is a non-empty set of subsets of W (i.e. of propositions) satisfying a number of properties, D is a non-empty domain of individuals, and I is an interpretation function for the non-logical part of the language. An assignment function g maps individuals variables x to elements of D, and propositional variables p to elements of P.

A satisfaction relation $\models_g$ may hold between a model M, a world w and a sequence of witnesses s from P, on the one hand, and a formula ϕ on the other.

$n(\phi)$ is the number of active existential propositional quantifiers in ϕ.

$$\begin{array}{llllllllll} n(Rx_1 \ldots x_n) & = & 0 & & n(\phi \wedge \psi) & = & n(\phi) + n(\psi) & & n(\neg\phi) & = & 0 \\ n(\exists x \phi) & = & n(\phi) & & n(\Diamond\phi) & = & 0 & & n(p) & = & 0 \\ n(\phi = \psi) & = & 0 & & n(\exists p \phi) & = & 1 + n(\phi) & & & & \end{array}$$

$$\begin{array}{lll} M, w, s \models_g Rx_1 \ldots x_n & \text{iff} & \langle g(x_1), \ldots, g(x_n) \rangle \in I(R)(w) \\ M, w, s \models_g \neg\phi & \text{iff} & M, w, cs \models_g \phi, \text{ for no } c \in P^{n(\phi)} \\ M, w, cs \models_g \phi \wedge \psi & \text{iff} & M, w, s \models_g \phi \;\&\; M, w, cs \models_g \psi, \text{ for } c \in P^{n(\psi)} \\ M, w, s \models_g \exists x \phi & \text{iff} & M, w, s \models_{g[x/d]} \phi, \text{ for } d \in D \\ M, w, s \models_g \Diamond\phi & \text{iff} & \exists v \; : \; wRv \;\&\; M, v, cs \models_g \phi, \text{ for } c \in P^{n(\phi)} \\ M, w, s \models_g p & \text{iff} & w \in g(p) \\ M, w, s \models_g \phi = \psi & \text{iff} & \forall v \; : \; M, v, cs \models_g \phi \text{ iff } M, v, ds \models_g \psi, \text{ for } c \in P^{n(\phi)}, d \in P^{n(\psi)} \\ M, w, qs \models_g \exists p \phi & \text{iff} & M, w, s \models_{g[p/q]} \phi, \text{ for } q \in P \end{array}$$

Disjunction $\vee$, implication $\rightarrow$, universal quantification $\forall$, and necessity $\Box$ are defined as standard in terms of $\neg, \wedge, \exists$, and $\Diamond$.

Truth: $M, w \models_g \phi$ iff $\exists s \; : \; M, w, s \models_g \phi$

Entailment: $\phi \models \psi$ iff $\forall M, \forall w, \forall g \; : \; M, w \models_g \phi \Rightarrow M, w \models_g \psi$

Alternative sets: $\text{ALT}(\phi)_{M,g} = \{\{w \mid M, w, s \models_g \phi\} \mid s \in P^{n(\phi)}\} \backslash \emptyset$

$[\![\phi]\!]_{M,w,g}$ and $[\![\phi]\!]_{M,w}$ denote the extension (truth value) and intention (proposition) of ϕ in M with respect to (w and) g, respectively.

$$\begin{array}{lll} [\![\exists x A(x)]\!]_{M,w,g} = 1 & \Leftrightarrow & \exists p \in \{[\![A(x)]\!]_{M,g[x/d]} \mid d \in D\} \; : \; w \in p \\ [\![A \vee B]\!]_{M,w,g} = 1 & \Leftrightarrow & \exists p \in \{[\![A]\!]_{M,g}, [\![B]\!]_{M,g}\} \; : \; w \in p \end{array}$$

Figure 12: Fragment from Aloni 2007

VOCABULARY

- variables over partial individual concepts: $x, y, \ldots$
- variables over worlds: $w, w', \ldots$
- variables over propositions/set of worlds: $p, p', p^{cs}, \ldots$
- individual constants: JOHN, ...
- properties: WOMAN, ...
- binary relations: VISIT, ...

SEMANTICS

Models: $\mathfrak{M} = \{\mathfrak{D}, \mathfrak{W}, \mathfrak{I}\}$, where the domain of individuals $\mathfrak{D}$ and the domain of possible worlds $\mathfrak{W}$ are disjoint, and the basic interpretation function $\mathfrak{I}$ assigns a subset of $\mathfrak{D}^n$ to any n-ary relation R relative to any worlds $\mathbf{w}$: $\mathfrak{I}_{\mathbf{w}}(R) \subseteq \mathfrak{D}^n$.
The interpretation function has the form $[\![\cdot]\!]^{\mathfrak{M},\langle g,h\rangle}$, i.e., formulas denote binary relations between an input assignment g and an output assignment h. Superscript $\mathfrak{M}$ is usually omitted.

a. $[\![x = y]\!]^{\langle g,h\rangle} = \mathbb{T}$ iff $g = h$ and $h(x) = h(y)$

b. $[\![x = \text{JOHN}]\!]^{\langle g,h\rangle} = \mathbb{T}$ iff $g = h$ and $\mathbf{Ran}(h(x)) = \{\mathfrak{I}(\text{JOHN})\}$

c. $[\![p = p']\!]^{\langle g,h\rangle} = \mathbb{T}$ iff $g = h$ and $h(p) = h(p')$

d. $[\![p \subseteq p']\!]^{\langle g,h\rangle} = \mathbb{T}$ iff $g = h$ and $h(p) \subseteq h(p')$

e. $[\![R_p(x_1, \ldots, x_n)]\!]^{\langle g,h\rangle}$ presupposes that for any $i \in \{1, \ldots, n\}$, $h(p) \subseteq \mathbf{Dom}(h(x_i))$;
If its presuppositions are satisfied, $[\![R_p(x_1, \ldots, x_n)]\!]^{\langle g,h\rangle} = \mathbb{T}$ iff $g = h$ and for all worlds $\mathbf{w} \in h(p)$, $\langle h(x_1)(\mathbf{w}), \ldots, h(x_n)(\mathbf{w})\rangle \in \mathfrak{I}_{\mathbf{w}}(R)$

f. $[\![[w]]\!]^{\langle g,h\rangle} = \mathbb{T}$ iff for any variable v (of any type) s.t. $v \neq w$, we have that $g(v) = h(v)$

g. $[\![[p]]\!]^{\langle g,h\rangle} = \mathbb{T}$ iff for any variable v (of any type) s.t. $v \neq p$, we have that $g(v) = h(v)$

h. $[\![[x_p]]\!]^{\langle g,h\rangle} = \mathbb{T}$ iff for any variable v (of any type) s.t. $v \neq x$, we have that $g(v) = h(v)$ and
$$\begin{cases} \mathbf{Dom}(h(x)) = h(p^{cs}) & \text{if } p \subseteq p^{cs} \text{ is the at-issue proposal} \\ \mathbf{Dom}(h(x)) = h(p) & \text{otherwise} \end{cases}$$

i. $[\![\varphi \wedge \psi]\!]^{\langle g,h\rangle} = \mathbb{T}$ iff there exists a k such that $[\![\varphi]\!]^{\langle g,k\rangle} = \mathbb{T}$ and $[\![\psi]\!]^{\langle k,h\rangle} = \mathbb{T}$

j. $[\![\mathbf{max}^p(\varphi)]\!]^{\langle g,h\rangle} = \mathbb{T}$ iff
   a. $[\![[p] \wedge \varphi]\!]^{\langle g,h\rangle} = \mathbb{T}$ and
   b. there is no h' s.t. $[\![[p] \wedge \varphi]\!]^{\langle g,h'\rangle} = \mathbb{T}$ and $h(p) \subsetneq h'(p)$

k. $[\![\text{NOT}_p^{p'}(\varphi)]\!]^{\langle g,h\rangle} = \mathbb{T}$ iff
   a. $[\![\mathbf{max}^{p'}(\varphi)]\!]^{\langle g,h\rangle} = \mathbb{T}$ and
   b. $h(p) \cap h(p') = \emptyset$

l. $[\![\text{MIGHT}_p^{p'}(\varphi)]\!]^{\langle g,h\rangle} = \mathbb{T}$ iff
   a. $[\![\mathbf{max}^{p'}(\varphi)]\!]^{\langle g,h\rangle} = \mathbb{T}$ and
   b. for all $\mathbf{w} \in h(p)$, $\mathbf{MB}(\mathbf{w}) \cap h(p') \neq \emptyset$

Figure 13: Fragment from AnderBois et al. 2013

VOCABULARY

- Atomic expressions $\mathsf{A}, \mathsf{B}, \mathsf{C}$
- Declarative mood $\triangleright$
- Interrogative mood ?
- Imperative mood !
- Variable for fixing imperative addressee x
- Negation $\neg$
- Conjunction $\wedge$
- Disjunction $\vee$

SEMANTICS

Atomic and Connective Semantics: Given a space of possible worlds W, agents $x \in D$

1. *Atomics* $[\![\mathsf{A}]\!] = \{w \mid \mathsf{A} \text{ is true in } w\}$
2. *Negation* $[\![\neg\phi]\!] = W - [\![\phi]\!]$
3. *Conjunction* $[\![\phi \wedge \psi]\!] = [\![\phi]\!] \cap [\![\psi]\!]$
4. *Dusjunction* $[\![\phi \vee \psi]\!] = [\![\phi]\!] \cup [\![\psi]\!]$

Sentential Mood Semantics:

1. *Declarative* $[\![\triangleright\phi]\!] = [\![\phi]\!]$
2. *Interrogative* $[\![?\phi]\!] = \{[\![\phi]\!], W - [\![\phi]\!]\}$
3. *Imperative* $[\![!\phi(\mathsf{x})]\!]_{s,c} = \{\langle y, w\rangle \mid y = \mathit{add}_c \;\&\; w \in [\![\phi(\mathsf{x})]\!]_{s[x/\mathit{add}_c],c}\}$
   For a variable assignment s, context c, where add_c is addressee of c, and $s[x/\mathit{add}_c]$ is the assignment which differs at most from s in that it assigns x to add_c

A preference state R is a binary relation on a set of alternative propositions. It represents the preferences that are being taken for granted for the purposes of the interaction. $R(a, a')$ means that a is preferred to a'. C_R (issues at stake in R) is the set of (non-empty) alternatives related by R. c_R (information at stake in R) is the union of those non-empty alternatives. It is assumed that the agents always prefer their information to absurdity, so $\forall R : R(c_R, \emptyset)$.
A preference state with attention is a preference state R, plus a list of propositions being attended to: $S = \langle R, \langle p_0, \ldots, p_n\rangle\rangle$. The meaning of a sentence ϕ is a function from one preference state with attention S to another $S' : S[\phi] = S'$.

Figure 14: Fragment from Murray & Starr 2016

VOCABULARY

Types: The set of types of Ty_2 is the smallest set of strings such that:

i. e, s, and t are Ty_2 types

ii. If α and β are Ty_2 types, then $(\alpha\beta)$ is a Ty_2 type

- variables of type $\alpha \in \text{T}_2$
- constants of type $\alpha \in \text{T}_2$
- identity $=$
- lambda operator λ
- negation $\neg$
- universal quantifier $\forall$

Frames: A Ty_2 frame is a set $\{D_\alpha \mid \alpha \text{ is a } \text{Ty}_2 \text{ type}\}$ such that

$D_e \neq \emptyset$; $D_s \neq \emptyset$; $D_t = \{0, 1\}$; $D_{\alpha\beta} \subseteq \{F \mid F : D_\alpha \to D_\beta\}$ for each type $\alpha\beta$.

A Ty_2 frame is *standard* if $D_{\alpha\beta} = \{F \mid F : D_\alpha \to D_\beta\}$ for each type $\alpha\beta$.

SYNTAX

Define for each Ty_2 type a the set of Ty_2 terms of that type, as follows:

i. Every constant or variable of any type is a term of that type;

ii. If φ and ψ are tersm of type T (*formulae*) then $\neg\varphi$ and $(\varphi \wedge \psi)$ are formulae;

iii. If φ is a formula and x is a variable of any type, then $\forall x\varphi$ is a formula;

iv. If A is a term of type $\alpha\beta$ and B is a term of type α, then (AB) is a term of type β;

v. If A is a term of type β and x is a variable of type α then $\lambda x(A)$ is a term of type $\alpha\beta$;

vi. If A and B are terms of the same type, then $(A = B)$is a formula.

SEMANTICS

An *interpretation function* I for a frame $F = \{D_\alpha\}_\alpha$ is a function having the set of all constants as its domain such that $I(c_\alpha) \in D_\alpha$ for each constant c_α of type α.
A *standard model* is a tuple $\langle F, I\rangle$ s.t. F is a standard frame & I is an interpretation function for F.
An *assignment* is a function a taking variables as its arguments s.t. $a(x_\alpha) \in D_\alpha$ for each variable x_α of type α. Write $a[d/x]$ for the assignment a' defined by $a'(x) = d$ & $a'(y) = a(y)$ if $x \neq y$.
The *value* $|A|^{M,a}$ of a term A on a standard model $M = \langle F, I\rangle$ under an assignment a is defined in the following way:

i. $|c| = I(c)$ if c is a constant;
$|x| = a(x)$ if x is a variable;

ii. $|\neg\varphi| = 1 - |\varphi|$;
$|\varphi \wedge \psi| = |\varphi| \cap |\psi|$;

iii. $|\forall x_\alpha\varphi|^{M,a} = \bigcap_{d\in D_\alpha} |\varphi|^{M,a[d/x]}$;

iv. $|AB| = |A|(|B|)$;

v. $|\lambda x_\beta A|^{M,a} =$ the function F with domain D_β such that for all $d \in D_\beta$, $F(d) = |A|^{M,a[d/x]}$;

vi. $|A = B| = 1$ if $|A| = |B|$,
$= 0$ if $|A| \neq |B|$.

Figure 15: Fragment of Gallin's (1975) Ty_2 as in Muskens 1995a

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